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Review

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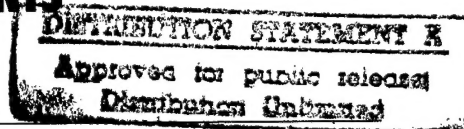
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THE HIDDEN IMPLICATIONS OF FORCE CHANGES

Dr. Rolf Clark

National security planners naturally draw on insights and experiences when making decisions. Past examples, national doctrine, organizational realities, threat development, technical knowledge, and fiscal analysis are used. This article explores another useful insight, one on the dynamics of system change. The system of interest concerns force levels. An increase or a decrease in force levels can lead to production dynamics that are unforeseen, and sometimes even impossible to meet. During the buildup of the 1980s, for example, the intention to achieve a 600-ship Navy, and related increases in aircraft forces, led to procurement levels that were ultimately unattainable within the budgets available. Industry could not accelerate production levels enough to meet force level increases largely because unit costs rose dramatically as demand stressed supply. The intent is to see why such production difficulties arise. The theory will present two important concepts in dynamic thinking. The first concerns the "accelerator," a concept which leads to instability: to bottlenecks and excesses. The second involves the distinction between "stocks" and "flows." Stocks and flows explain why accelerators occur. These concepts are not completely intuitive.

We see accelerators in almost every aspect of life. They apply to driving a car, to inventory control, and to the acquisition of forces. Each experiences system dynamics. These short-term "transient state" dynamics occur when a system is changed from one state to another—when force levels are raised as they were in the 1980s, or reduced as they have been in the 1990s.

Further, stocks and flows are the building blocks for understanding systems in change.

The "first-order effects" of system changes require crude examples, and certainly adjustments would be made in real life that smooth out the first-order changes. Yet first-order effects by definition dominate system change. Foreseeing the dynamics helps us plan force changes.

THE ACCELERATOR: DRIVING YOUR CAR

The accelerator principle is at work when you drive your car. Say you're doing 50 mph on a straightaway and want to accelerate to 60. You first step on the gas firmly, and as you reach 60 mph, ease back to steady up. To increase speed by 20 percent you may increase the flow of fuel by 300 percent (depending on how fast you accelerate) and then at 60—the new steady state—use only slightly more fuel than you first did at 50 mph. Speed only rises, but fuel flow goes up and down.

While speeding up—in the “transient state”—the fuel flow changes much more than the velocity of the car. That's an accelerator. The same principle applies to acquisition: force levels rise, but procurement goes up and then down.

STOCKS AND FLOWS

Procurement is a flow; the force level is a stock. Flows change faster than stocks. That's the accelerator relationship again.

Accelerators depend on the relationship between a system's stocks and its flows. A stock is an accumulation—an inventory, a summation, something that has been collected over time. It is measured in units like “aircraft,” or “tons,” or “boxcars.” The water in a bathtub (gallons) is a stock. The

inventory of cars at a Chevrolet dealer is a stock.

Flows, on the other hand, are measured in units like “aircraft per year,” or “tons per week,” or “boxcars per day.” Flows feed into and out of stocks. The water pouring through the faucet (gallons per minute) is an inflow; leaving through the drain, an outflow. New cars arriving at the dealer per week is an inflow; car sales per week, an outflow. Stocks have value at a point in time; flows only have value over a time interval. One can take a still photograph of a stock; but a seeing a flow requires a video recording.

In national finance, a stock would be the federal debt while a flow would be the annual federal deficit. Plant and equipment in a corporation would be a stock while investment and depreciation would be flows. Stocks are on a firm's balance sheet; they are assets and liabilities. Flows are on the income statement; they are the annual revenues and expenditures.

In national defense, flows are system deliveries, personnel recruitments, purchases of spare parts, shipments to and from inventories, and force inactivations. Stocks are force levels, personnel, inventories, systems in process of being produced, and systems in repair. The interactions between stocks and flows lead to temporary inventory shortages, delivery delays, force inadequacies, and pipeline instabilities.

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LOGICAL IMPLICATIONS

All systems can be modeled in terms of stocks and flows. Modeling systems using stocks and flows is an aspect of system simulation, and of "system dynamics" in particular. We cannot treat the discipline in detail here (see Forrester, 1968), but even with a simple system, several factors can be acknowledged.

If system stocks last a very long time, then the flows that maintain them will be small. If assets have a 30-year life, like Navy ships, in peacetime only about 1/30th of them leave each year and thus only 1/30th of them need to be replaced.

As a corollary, if the flows are small compared to the stock, then the stock changes slowly. The small flows mean long-lived force assets require lengthy periods of time to evolve into new configurations. The steady state in shipbuilding occurs about 50 years after a change, when the fleet has finally turned over.

Consider national investment. If national savings per year (a flow) is low, we will invest less and the economy cannot change rapidly. Countries like Japan and Korea, with much higher savings rates than the United States during the 1970s and 1980s, were able to shift their economies to new technologies far faster.

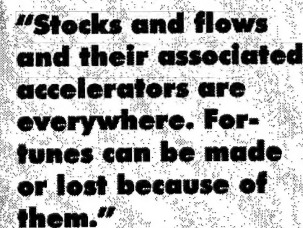
The dynamics are different for shorter lived systems. Information age systems like electronics and software reach obsolescence after four or five years, and have faster turnover rates. They consequently experience less severe transient dynamics, though they cost more to sustain at required levels.

STOCKS AND FLOWS ARE PERVASIVE

Stocks and flows and their associated accelerators are everywhere. Fortunes are made or lost because of them.

In 1970 there was a corn blight, and prices increased dramatically. Some traders bought pork futures, thinking they would profit when the price of pork rose. Pigs are corn-fed and a rise in corn prices would mean pork prices should also rise. This is indeed true in steady state, but not in the short-term transient state. In fact, pork dropped in price for six months after corn prices rose. Why? Pig farmers, knowing they could not afford the higher feed prices, slaughtered their breeding stock, causing an accelerated short-term flow of pork to the marketplace. The flow caused a glut, and instead of pork prices rising, they fell. A year later pork was indeed at far higher prices, but in the interim the traders had lost heavily (Meadows, 1970).

In the mid-1970s, long before the oil price reached its 1980 peak, a graduate student at the Massachusetts Institute of Technology reportedly advised his family—who owned oil tankers—to sell their fleet. He had observed that the flow of tankers in production was too large compared to the stock of existing tankers, and there would soon be excess tankers at sea. He was right. The utilization rate of the world's tankers fell from 120 percent in 1972 to 70 percent in 1979 to 40 percent in 1982. This lowered



"Stocks and flows and their associated accelerators are everywhere. Fortunes can be made or lost because of them."

the value of tankers, which soon were selling at far less than their building cost. The family reentered the market at its bottom, and by 1989 the utilization rate was again near 90% (Randers, 1984; Bakken, 1992).

SURGE DYNAMICS

We have argued that if the stock of assets is to be increased rapidly—as in mobilization or even surge—then the procurement inflow must increase dramatically. It is time to explore the accelerator and its dynamics more quantitatively. Consider Figure 1.

Suppose you want to increase an aircraft fleet from 80 to 100 in five years and that aircraft last 10 years. The eventual 100-aircraft force will then have 1/10th, or 10 of the aircraft retiring each year. To stay at 100 aircraft, 10 units need to be procured each year to replace those retir-

ing. The original 80 aircraft fleet required only 8 be built each year. But it is misleading to conclude that to go from a force of 80 to 100 means raising aircraft production from 8 to 10. Such steady-state thinking is incomplete. To raise the stock of aircraft from 80 to 100 requires adding 20 aircraft. To do this in five years means producing four extra aircraft each of the five years, or increasing the annual production flow from 8 to 12, a 50 percent increase as shown. At the end of the five-year buildup, since none of the 20 new aircraft need replacement, the production flow drops to 10. To increase the force assets by 25 percent over five years means the flow of aircraft being produced needs to suddenly increase by 50 percent—truly a building boom. A bust period, however, follows. This inevitable boom-to-bust dynamic is the accelerator at work.

This simple analysis has ignored attrition, which could be accommodated but

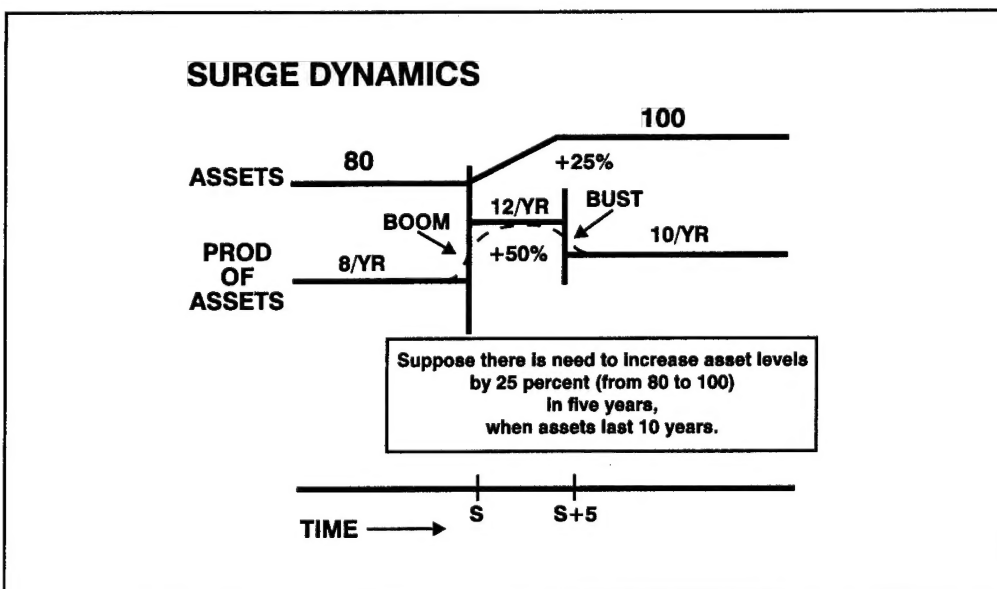


Figure 1. Surge Dynamics—Production of Assets

does muddy the discussion. In a peacetime buildup, attrition would not be a factor. In war it would significantly increase the dynamics as first production would need to accelerate even more to accommodate the attrited units. Then by ceasing hostilities, there would be an even larger drop as attrition ceases the same time reduced force levels are needed. Thus the accounting would involve more arithmetic, but the concept would be the same.

Another caveat is that the above has assumed units are only bought or inactivated. They might also be updated through modernization. This again complicates the analysis beyond the discussion intended here, though modernization can also be accommodated. One wants a computer simulation to do so. Equipment upgrades extend the life of systems, and are a way to ameliorate sudden increases in procurement by spreading expenditures out over time. One then needs to maintain information on system age, and prepare for eventual block obsolescence.

Furthermore, adjustments in the analysis can be made for the possibility of cannibalizing inactivated systems. Cannibalizing means less need for replacement. This would reduce the accelerated production during buildup, but the bust period associated with downsizing would be even more severe as equipments would be older, on average, due to the cannibalized parts.

Such qualifiers provide the second- and third-order considerations. The dotted line in the above indicates there will be ways to smooth out the severity of the first-order impacts discussed so far, though the attrition aspect actually amplifies them.

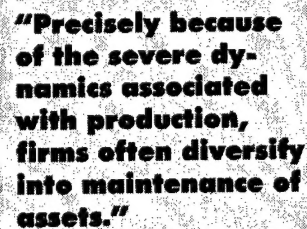
THE ATTRACTION OF MAINTENANCE

Precisely because of the severe dynamics associated with production, firms often diversify into maintenance of assets. Maintenance is closely related to force levels, which vary far less than procurements. If a firm—such as an aircraft engine manufacturer—can augment its production business with maintenance services, its financial fortunes will be more stable. From automobile agencies to aircraft engine manufacturers to shipyards, maintenance business becomes a stabilizing force.

UPSTREAM PRODUCTION HAS AMPLIFIED DYNAMICS

Returning to our simple example to see what more can be drawn out, the 50 percent sudden increase in the flow of production, compared to the 25 percent increase spread over five years in the stock of assets, is a large difference. Production flows translate into jobs and raw materials. The first point, then, is that even small and gradual increases in force levels will mean large sudden increases in jobs and materials.

There is more. Upstream production—that further up the manufacturing process—will experience even greater dynamics. Consider the Figure 2, which expands Figure 1.



“Precisely because of the severe dynamics associated with production, firms often diversify into maintenance of assets.”

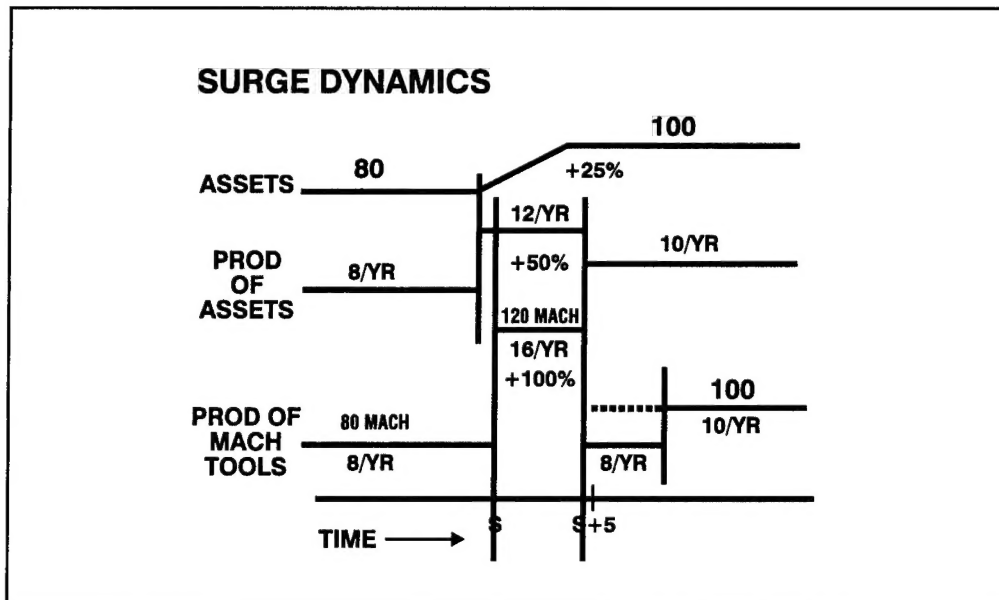


Figure 2. Surge Dynamics—Upstream Production

Suppose that it takes on average 10 production “machines” (metal benders, cutters, lathes, welders, computers, etc.) to produce one aircraft per year. Then a factory needs 80 machines to produce eight aircraft per year. If these “machines” also last 10 years on average, then eight machines need to be procured by the factory each year to replace those machines wearing out. During the buildup, however, production is raised to 12 aircraft per year, and thus about 120 machines are needed. To get from 80 to 120 machines in five years the factory must buy 16 machines per year for five years—eight to replace those ending their useful life plus another eight each year for five years to get 40 more machines. While aircraft assets have increased 25 percent and aircraft production 50 percent, machine production must increase 100 percent, from 8 to 16. After reaching the desired level of machines,

machine tool production experiences a bust period, followed by a recovery when steady state is finally reached. Upstream production dynamics are severe.

Machine tools are further up the production stream, as they produce the machines that produce the assets. In 1945, J. A. Krug, then Chairman of the War Production Board, reported on the criticality of machine tools during the World War II: “The timing varied for different products and different industries, but in general the acute shortage as the defense effort first got underway was in the facilities... plant, equipment, and above all, machine tools” (War Production Board, 1945).

Capital equipment sectors continue to experience wide swings. Between 1981 and 1983 the U.S. machine tool sector lost 60 percent of its annual new orders (AMT, 1992–93). Machine tools are only one example of the upstream production fac-

tors. Plant and equipment, commercial real estate, as well as factories, mills, and refineries, also are driven by such dynamics.

Clearly, planners will want to anticipate such impacts on the industrial base when force level changes are planned.

LONG- VERSUS SHORT-LIVED ASSETS

Ships and oil equipment and real estate have long lives. Industries producing goods with shorter life spans, like electronic equipment, will experience less severe production dynamics. Since they decay more rapidly, their flows are relatively large compared to their stocks. They "turn over" faster. As a result their production booms and busts are more contracted in time, and less severe in amplitude.

Let's translate the above 80 to 100 aircraft example into an analogous \$80 million to \$100 million electronic system. If the electronic components last only five years, the \$80 million program will require 20 percent of its value, or \$16 million of procurement per year, to retain its original value. Increasing the system's value to \$100 million in five years means increasing procurement budgets by \$4 million per year—from \$16 million to \$20 million—a 25 percent increase. Thus while aircraft that lasted 10 years required a 50 percent increase in procurement to raise assets by 20 percent, the electronic system with assets lasting only five years required only a 25 percent increase in procurement to obtain the same proportional growth in the same time. Systems with shorter life spans require less severe dy-

namics during change. The information age, with shorter system lives as well as more agile production, may experience less severe system dynamics.

A WORD ON BUDGETS

We have seen that procurement, and therefore procurement budgets, change dramatically when force levels change. Operations and maintenance (O&M) budgets and personnel budgets, on the other hand, do not experience the same dynamics. They are closely related to force assets, and change primarily as force levels change. Since 1974 the defense procurement budget has varied by an average of 12 percent in year-to-year changes. The overall budget itself has varied year by year by only

five percent. The changes to O&M and personnel budgets, making up most of the residual after procurement, is deducted from the budget, and must logically vary much less. The average annual change of ownership budgets has been between one and two percent.¹

Understanding system dynamics should help improve budget development, especially regarding the long-term needs for ownership budgets associated with the force levels.

"Understanding system dynamics should help improve budget development, especially regarding the long-term needs for ownership budgets associated with the force levels."

¹ Some care must be taken in thinking about this. Planned O&M budgets often swing widely, but executed O&M budgets do not, for they ultimately support force assets, and assets do not change rapidly.

DEFENSE BUILD-DOWNS AND DECELERATORS

Opposite dynamics from the above are at work during force level reductions. Procurement falls far more than force levels. For example, by 1993 military aircraft assets had decreased about 30 percent from 1989 levels. Yet the military engine sales of U.S. engine producers had decreased 70 percent.²

This is logical. Just as you ease up on the gas to slow down your car, and then increase gas flow again once you reach your desired lower speed, so aircraft engine sales must drop dramatically, and then rebound somewhat, once the military stabilizes at lower force. Then, analogous

"More recently, decelerators have forced reductions in defense facilities and jobs. The argument here is that the dynamics are predictable."

to the force increase dynamics, production will partly rebound as the new steady state is reached. This rebound should be anticipated.

For example,

the backlog of orders for military aircraft engines actually rose in 1995, after dropping steadily for the previous six years as aircraft inventories fell. Aircraft levels themselves did not increase in 1995, but they stopped their rapid decline. This relative stabilization led to the increase in backlog (AIAA, 1996-97).

WHAT IS NEEDED

Understanding acquisition and logistics dynamics requires stock and flow think-

ing. The above samples are simplified, and more complex problems need consideration. Yet the stock-flow logic and what it tells us needs its place in the policy makers' set of analytic tools. Such considerations will help managers see that inventories in the spare parts pipeline will often be far from intended levels—sometimes too high, sometimes far too low. Deliveries suffer, lead times expand, and prices rise. In the 1980s buildup, lead times on many items soared, and unit prices rose dramatically with the surge. More recently, decelerators have forced reductions in defense facilities and jobs. The argument here is that the dynamics are predictable.

A more subtle insight is embedded in the accelerator-decelerator paradigm. An initial cutback in force levels leads to a reduction in production as we have seen, which leads to a cutback in orders for production equipment (machine tools) as we have also seen. But if this production capacity cutback is done without looking ahead to the recovery phase of the decelerator, then there will not be enough production capacity to recover when needed. In the aircraft example, when production stabilizes, there may not be enough machine tools to produce the new demand and machines must first be used to produce more machines. This "bootstrap" problem is endemic to accelerators.

Nobel prize winner Herbert Simon's claim in the 1950s that the human mind cannot solve the complex problems of the real world is less true today. His principle of "bounded rationality" still holds, but we can do far more exploration with computers than we could with the mathematics

² Data provided by Aerospace Industries Association, Washington, DC.

of 1957 (Simon, 1957). System dynamics such as discussed here are now easily modeled and should be implemented. This would require a reasonable simulation effort that captures the necessary intricacies of force level procurement and support.

For now, incorporating the accelerator logic in policy thinking is beneficial. Computer simulations that quantify the inter-

relationships between systems and determine the magnitudes and timing of these dynamics will naturally follow. The modeling mathematics are state of the art. The policy implications are important. Planners need to ensure that transient state dynamics are adequately captured in the policy making process.

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SOME NEW APPROACHES TO "REWARD" CONTRACTING

William N. Washington

This article looks at some new ideas on "Reward" contracts, and how some older ones might be modified to improve their usability. Specifically, it deals with three different contract vehicles for rewarding a contractor's performance enhancement, cost savings, or schedule savings that exceed the minimum requirements specified by the government. The purpose behind reward contracting is to offer an inducement to the contractors to go beyond business-as-usual development programs, and attempt to produce innovative processes or products that subsequently benefit the government. This is in keeping with some suggestions made by former Under Secretary of Defense for Acquisition and Technology Dr. Paul Kaminski and Colleen Preston, former Deputy Under Secretary of Defense for Acquisition Reform, concerning incentivizing change away from the one-size-fits-all mode of contracting, and providing more information to the source selection authority for cost tradeoffs. I discuss three types of reward contracts (i.e., incentive, award fee, and research tournaments), and suggest what might be done to improve them. An approach to provide more contract vehicles for consideration in the contracting process, called "research tournaments," seems to have merit.

In January of 1995, Dr. Paul Kaminski, then Under Secretary of Defense for Acquisition and Technology, discussed his concept of the challenges to be faced with decreasing defense budgets, and the need to reduce the cost of weapon system procurements at the Industrial College of the Armed Forces. He emphasized the need to adopt a more balanced approach to the cost-performance relationships in our procurements, stressing the

need to do up-front tradeoffs, and assessments of the incremental cost requirements. He stated that the results of these analyses should be made available to the decision makers early in the source selection process, so they could take them into consideration. He also mentioned the need to incentivize change away from the one-size-fits-all mode that we have followed in the past. Colleen Preston (1995), former Deputy Under Secretary of Defense for

Acquisition Reform, also stressed these points in her testimony before the House Government Reform and Oversight Committee.

Here I'll discuss some of the new ideas on competition, and how some older ones might be modified to improve their usefulness. Specifically, I'll explain three contract vehicles for rewarding a contractor's performance enhancement, cost savings, or schedule savings that exceed the minimum requirements specified by the government. This is in keeping with the new Department of Defense (DoD) Directive 5000.2-R (1996), which stresses cost management incentives.

The purpose behind "reward" contracting is to offer an inducement to contractors to go beyond business-as-usual development programs, and attempt to produce innovative processes or products that subsequently benefit the government (Rogerson, 1989). This is based upon the premise that if the reward to the manufacturer is low, quality manufacturers will not be interested in doing business with the government. For instance, if profits are limited to 10 percent of the contract award, only contractors who normally make less or equal to that in the private sector will be willing to bid on the contract; contractors who normally make more will not be willing to bid and subsequently lose money by accepting those contracts (Lucas, 1996). Confirmation of this trend is shown by the recent sale by several con-

tractors of their government divisions, so they can focus on the more lucrative commercial market (Beltramo, 1996). In support of the reward premise, recent industry comments have suggested that the government share some of its savings with industry, when industry has made an investment that produced savings for the government (*National Defense*, 1996).

HISTORY OF "REWARD" CONTRACTING

INCENTIVE CONTRACTING

Under this type of contract, the incentive payment varies based upon the contractor's ability to satisfy specific formula-driven cost or performance objectives. A precise definition of the factors that will be used to determine the incentive fee to be paid is negotiated in advance, and allows some of the profit loss or gain to be shared between the government and the contractor, based on the contractor's ability to reach the target goal. The objective of an incentive contract is to motivate the contractor to earn more compensation by achieving better performance and by controlling costs.

Problems with incentive contracting. These contracts have not been found to be especially effective in reducing costs, nor speeding up schedule, but they do generally meet performance goals, according to DeMong (1984), who reviewed several previous studies (Belden, 1969; DeMong,

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1978; Hunt, 1971; Hunt, Rubin and Perry, 1971; Jameson, 1979; and Williams and Carr, 1981). The GAO (1987) performed a review of 62 DoD incentive contracts to determine if this type of contracting met the theory concepts it was supposed to follow. Their findings were consistent with the theory that the final costs for the programs would fall around the target price set at contract award (the majority of the contracts fell within 5 percent of the target), with 47 percent of the contracts falling under the target and 53 percent falling over the target price. However, 21 percent of the contracts exceeded the ceiling price where the government liability ended. They also found that there was no relationship between the cost-sharing ratio and the achievement of a contract's target price, which runs against the theory that as a contractor's share ratio increases, the contractor has a greater incentive to meet or underrun the target costs.

AWARD FEE CONTRACTING

In this type of contract, the government assigns priority to what kinds of things it considers important and will pay an award fee for. These types of contracts have been in use since 1962, when the National Aeronautics and Space Administration and the Navy began to use them. Its purpose is to encourage the contractor to surpass the minimum acceptable level of performance established in the contract, for areas ranging from cost to schedule to performance. This type of contract varies from the incentive contract, in that the award is subjective and based upon after-the-fact evaluations to determine the amount of the award. Award fee contracts have gener-

ally been found effective in improving contractor performance, according to Beeckler and Correia (1982), and DeMong (1984), who reviewed a number of previous studies (Brown, 1976; Buck, 1974; Byers, 1973; Carter, 1977; DeJong, 1978; Egan, 1968; Hunt, 1982; Kneppshield, 1976; Larsen, 1978; and Williams and Carr, 1981).

Several authors attribute the success of this type of contract over incentive contracts to the involvement and periodic performance evaluations performed on the contracts (Jameson, 1979; Keathley, 1994). Originally, this type of contract was limited to cost plus contracts, but Francom (1989) recommended that they should be expanded to include fixed price contracts, which they currently have been.

Problems with award fee contracting.

This type of contract requires significant technical and managerial oversight to continually monitor and communicate with the contractor about their work effort, since the awards are made as often as the government wants throughout the contract's life (DeMong, 1984; Hogenmiller, 1992; Schade, 1990). A problem may also exist with the determination of the contractor's performance, because of the subjective nature of the decision process that determines the amount of the award fee (GAO Study, 1991; Isbell, 1992). This GAO review of the Department of Energy Award Contracts (1991) recommended improvement in three areas. The first was to develop specific, mea-

"Award fee contracts have generally been found effective in improving contractor performance...."

asurable performance objectives to supplant what had been used previously. Second was to develop procedures that appropriately reflected the results of the on-site reviews in the performance evaluations, and that tracked the contractor's responses to previously identified deficiencies. Finally, they recommended new procedures and training to implement these

"This process [research tournaments] should promote innovation on the part of the offerors, and provide firmer cost estimates for equipment, since costs would be based upon completed hardware versus conceptual hardware estimates."

recommendations. In summary, the GAO report stated that to achieve these new procedures, more time would have to be spent on day-to-day operations and procedures, which would possibly require more staff to re-

view the processes. Isbell (1992) also discussed some NASA recommendations, whereby these contracts should have a negative or zero fee, if the contractor's performance were not up to expectations.

Suggestions. One way to address this problem would be for the contractor to specify in his proposal what he would consider to be appropriate rewards for specific goals (Fullerton, 1995a). This would allow the source selection committee to perform the up-front tradeoffs and assessments of the incremental cost requirements that Kaminski (1995) has suggested. It would also reduce the arbitrary nature of what constitutes an improvement, and make the award equal to what the contractor feels it should be worth.

This simple process would eliminate most of the problems associated with award fee contracts, and also save time and effort on the part of the government.

RESEARCH TOURNAMENTS

Recently, Fullerton (1995a and 1995b), Fullerton and McAfee (1996), and Taylor (1995) have expressed some novel and interesting proposals concerning competition. In these "research tournaments," the competition procedure is structured as an auction and prototype competition, with the winner awarded a "prize" for the best product. The auction component consists of the participants paying a fee for entering the tournament, which could be used to defray the cost of the prize, or offset the cost of conducting the competition.

The government would commit to pay the research tournament winner a prize that would be verifiable by the courts (i.e., a prize that must be awarded). The selection of the winner would be based upon specified priorities (e.g., performance or cost) established by the government, which would be specified in the request for proposal, so that the competing firms would know which innovations or priorities were most important in winning the prize. Finally, each firm would submit its prototype at the end of a specified period of time, for the government to evaluate and subsequently award the prize for the best product. Thus, the competition would differ from a patent competition, in that it would select the most innovative design across a group of offerors that would win, with the quality of the design stressed over the date of discovery.

This process should promote innovation on the part of the offerors, and pro-

vide firmer cost estimates for equipment, since costs would be based upon completed hardware versus conceptual hardware estimates. Rich and Janos (1994) also point out "the beauty of a prototype is that it can be evaluated, and its uses clarified, before costly investments for large numbers are made." This is also in keeping with DoD Directive 5000.1 (1996), which stresses modeling and simulation of new systems. An additional benefit of this type of procurement is that it should require less government oversight, since the offeror has already developed the item, and is offering it at a fixed price to the government. Thus, concern about overseeing development and production costs is negated. Finally, as mentioned above, the contractors could specify along with their proposals what they consider to be appropriate rewards or fees for additional or alternative performance goals. This would allow the source selection authority to perform up-front tradeoffs and assessments.

This type of contract would seem most suited for procurements that have either spin-on or spin-off possibilities, and where there are opportunities for commercial application of the developed product. This would prompt the developer to risk capital investments in the hope of significant commercial gains. The concept behind this type of procurement is not new. The first instance of its use was seen in the development of the steam locomotive in England in 1829 (Day, 1971), where £500 was awarded for the "fastest" steam locomotive that met the railroad's requirements. In this contest, five offerors entered, but three of the locomotives did not meet the requirements stated by the railroad, so competitive races were run be-

tween the remaining two locomotives, the "Rocket" and the "Novelty." The Rocket was the eventual winner, with the Novelty breaking down on one of the competitive trial runs. This example demonstrates one of the advantages of a prototype competition, in that the demos can be tested in a face-off, which would reveal design problems that may not be obvious in a review of design drawings. More recently, the selection of the high-definition TV standards (*The Economist*, 1993), and the Air Force's Advanced Tactical Fighter (Easterbrook, 1991; Opall, 1991) were based upon prototype competitions. Opall (1991) points out that while the contractors were not happy with investing so much money up-front on a program, they do expect to recover their investments with a profit on the system within 10 years, and considered that the technologies they developed as part of their effort would give them a leg up on future contracts.

One of the difficulties of a prize process is determining what the amount of the prize should be. One approach would be to set the award to a level commensurate with what the government felt the work effort to be worth; but, as with the award fee, would have problems with its arbitrary nature. Another approach has been suggested by Rogerson (1989), which would involve basing the prize on a formula that uses the price of a company's stock. In that way, the prize could vary from one company to another, but it would still have the same magni-

"One of the difficulties of a prize process is determining what the amount of the prize should be."

tude of importance to the offeror. This approach would allow for computing the prize in advance, so the source selection authority could use that information in its determination.

Fullerton (1995a) has suggested that the contractor specify in his proposal what he would consider to be an appropriate reward for his efforts, and that amount, like Rogerson's, could be taken into consideration in the source selection. Or, if the contract award was large enough, or had commercial applications, the award could constitute just the winning of the contract, since the follow-on work would generate sufficient commercial incentives for the company. With these various alternative approaches to determine the nature of the award, it would depend upon the type of procurement as to which method would be more appropriate.

SUMMARY

In keeping with Dr. Kaminski's recommendations concerning incentivizing change away from the one-size-fits-all mode of contracting, these contract vehicles—incentive contracting, award fee contracting, and research tournaments—should be viewed as approaches that can be used to bring benefits to the modernization of government equipment. The specific type of reward contract to use to achieve these benefits would seem to be dependent upon the type of benefit desired, the amount of government oversight available, and the amount of risk placed upon the contractor.

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THE GOVERNMENT PERFORMANCE AND RESULTS ACT: STRATEGIC PLANNING OF THE FUTURE

Beryl Harman

The Government Performance and Results Act (GPRA) was signed into law on Aug. 3, 1993. In the view of the Office of Management and Budget (OMB), it is intended to shift the focus of government officials from program inputs to program execution. The goal is to better see what is being achieved and how well government programs meet intended objectives, rather than accept the old bottoms-up estimating methodology. As Whittaker (1995, p. 60) contends, "... the law is simple and straightforward; don't emphasize what funds have been spent or what level of activity has been accomplished, but show the results of your efforts." This paper will explore the tenets of GPRA, particularly those associated with strategic planning. It will also address some of the history, implementation, and potential consequences of the Act.

The Government Performance and Results Act's objective is "to provide for the establishment of strategic planning and performance measurement in the Federal Government, and for other purposes." It bases this objective on the findings that:

1. Waste and inefficiency in federal programs undermines the confidence of the American people in the Government and reduces the Federal Government's ability to address adequately vital needs;

2. Federal managers are seriously disadvantaged in their efforts to improve program efficiency and effectiveness, because of insufficient articulation of program goals and inadequate information on program performance; and

3. Congressional policymaking, spending decisions, and program oversight are seriously handicapped by insufficient attention to program performance and results.

It then goes on to state the purposes of the Act is to:

1. improve the confidence of the American people in the capability of the Federal Government, by systematically holding federal agencies accountable for achieving program results;

2. initiate program performance reform with a series of pilot projects in setting program goals, measuring program performance against those goals, and reporting publicly on their progress;

3. improve Federal program effectiveness and public accountability by promoting a new focus on results, service quality, and customer satisfaction;

4. help Federal managers improve service delivery, by requiring that they plan for meeting program objectives and by providing them with information about program results and service quality;

5. improve congressional decision making by providing more objective information on achieving statutory objectives, and on the relative effectiveness and efficiency of federal programs and spending; and

6. improve internal management of the Federal Government.

With these findings and purposes in mind, each agency was required to submit a strategic plan to the Director of the Office of Management and Budget (OMB) and to Congress by Sept. 30, 1997, with the first annual Performance Plan for fiscal year 1999. This strategic plan must include a comprehensive mission statement; a description of outcome-related general goals and objectives and the operational processes and resources required to meet these goals; a description of the relationship between performance goals and general goals and objectives; an identification of key external factors that could effect achievement; a description of program evaluations used to establish or revise goals and objectives; and a schedule for future program evaluations.

The initial plan must cover a period of not less than five years, computed forward from the fiscal year in which it is submitted; and must be updated at least once every three years. The agency must consult with Congress on the plan's formulation and must consider the views of those affected by, or interested in the plan (i.e., the customer or stakeholder in the process). In addition, the planning is consid-

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ered an inherently governmental activity, which means it cannot be performed by private enterprise. Only the Central Intelligence Agency (CIA), the General Accounting Office (GAO), the Panama Canal Commission, the United States Postal Service, and the Postal Rate Commission are exempted from the provisions of the Act.

As a result, practically all the Executive agencies, including Department of Defense (DoD), have to establish strategic plans that comply with the Act's performance requirements. Strategic plans will form the basis of, and result in, the establishment of annual performance plans, based on measurable goals, that will define effective or successful programs. To accomplish these plans, each agency has been given the flexibility to aggregate, disaggregate, or consolidate program activities, providing that agencies adhere to current requirements. There are also new terms to be used ("outcome measures," "output measures," "performance goals," "performance indicators," "program activities" and "program evaluation") when implementing GPRA.

In the fiscal year 2000 budget submission, DoD (along with other Executive agencies) is required to submit, through OMB, the first program performance report to Congress and the President. This report will document how well the agency is performing and whether it has accomplished what it proposed to do. It will discuss the performance indicators that were used, the program results (success or failure) that were measured, any problems experienced with performance goals, and factors affecting performance that were beyond the control of the agency involved. Theoretically then, in the future, Congress and the President will be able to decide

whether to continue DoD programs, revise programs, or totally cancel programs they perceive as an ineffective use of government funding based on the performance information submitted in the performance report. This will, in turn, allow Congress and the President to construct a national budget that is meaningful—based on actual government performance—and to construct a budget that will receive favorable public acceptance.

"Strategic plans will form the basis of, and result in, the establishment of annual performance plans, based on measurable goals, that will define effective or successful programs."

There were also a significant number of pilot projects authorized under the Act (Barr, 1994, Panetta, 1994). These projects provided participating agencies with valuable experience. Within DoD, the Defense Logistics Agency (DLA), Air Combat Command, the Army Research Laboratory, the Defense Commissary Agency, the U.S. Army Corps of Engineers (Civil Works), the Army Audit Agency, and CINCLANTFLT (Carrier Battle Group) all participated in pilot projects. Results from these pilots have shown that GPRA is flexible enough to accommodate the needs of organizations having significantly diverse missions.

One part of the pilot program process has not been successful—that having to do with managerial flexibility and accountability. GPRA allowed agencies to propose and OMB to approve waivers of certain nonstatutory administrative requirements and controls (e.g., staffing, re-

muneration, and funding transfers) to allow for more managerial flexibility and accountability. To date, no waivers have been approved under this authority. This is due in part to elimination of the bulk of the "Federal Personnel Manual," enactment of the Federal Workforce Restructuring Act, and the ability to approve waivers under existing administrative authorities independent of GPRA. Therefore, some internal changes to administrative requirements have been possible without implementation of the waiver process.

"In the context of administrative reform, government reform occurred on two levels: political and managerial."

What then generated the need for GPRA? Why did Congress feel compelled to write such a law and impose this type of strategic management system on the Executive agencies?

HISTORY

It is somewhat difficult to determine the underlying impetus of GPRA statutory requirements. It can be looked at in the context of administrative reform (Rosenbloom, 1995), budget reform, (Rubin, 1993), the history of planning, (Mintzberg, 1994), or more simply, the emphasis on efficiency and effectiveness that has formed the underpinnings of governmental reform since the signing of the Constitution. In fact, the desire for efficiency and effectiveness is the major political force that drives our national policies and priorities. This is true whether we ascribe to the "effective" government of

the National Performance Review (NPR) or the "efficiency" of a balanced budget as stated within the *Contract with America*. Therefore, since its antecedents are vague, we can only make some generalizations and then consider recent history in the development of the Act itself.

In the context of administrative reform, government reform occurred on two levels: political and managerial. These are defined as fundamental redefinitions of public administration which occurred to fit a particular political need or vision (political); and adjustments within the existing administrative framework (managerial) (Rosenbloom, 1995). On the political level, this has been translated into four fundamental approaches to public administration, with the National Performance Review a possible fifth.

The first approach, perceived as the "administration by gentlemen," was employed between 1789 and 1828. In this era "voting privileges were restricted and positions in federal service were viewed loosely as property and often held for life" (Rosenbloom, p. 3). The second approach, the "spoils system," was in play from 1829 to the 1880s. This system was aimed at delivering "federal service into the arms of the political party in power" through favoritism and patronage (p. 3). The third theory of public administration, which Rosenbloom calls "the merit system and political neutrality," was put in practice from 1883 to the 1930s. This system sought to destroy the political machines and defined public administrators as "legally insulated, politically neutral, trained experts" who should be promoted based on merit (i.e., performance) (p. 4). The fourth, "the New Deal," from 1933–1939, placed emphasis on selecting appointees

based on "policy agreement and ability rather than partisanship alone" and established the Bureau of the Budget (now known as the Office of Management and Budget) within the Executive Branch (p. 4). Finally, the NPR, from 1993 to the present, seeks to establish an entrepreneurial, competitive, customer-driven, results-oriented public administration, with an administrative capacity to intervene in the society and economy, "strengthen executive control and drastically reduce congressional involvement" (p. 4).

On a managerial level, reforms have been aimed at improving performance and at fashioning adjustments within the administrative framework. These reforms can be identified as process reforms (e.g., the planning, programming, budgeting system or total quality management), and structural reforms (e.g., creation of the Office of Management and Budget in 1970). Each activity in turn, has left, or is leaving, a legacy of change.

Therefore, in terms of administrative reform, the GPRA is a hybrid of the process and structural reform movements. As Rosenbloom contends, it is politically connected to NPR, but is institutionally at odds with it, since in his opinion it grants Congress more power in dealing with administrative agencies by effectively making the agencies an extension of the legislature in the refinement of legislative goals. Further, it uses strategic planning to develop or reduce agency missions.

Focusing on budget reform, we see a slightly different picture. As Rubin points out, the need for budget reform grew out of the need for clear financial reporting to provide greater public accountability of government funding. The railroads during the late 1800s took a heavy toll on public

finances because they not only borrowed heavily from private sources, but were often government subsidized. While important to commerce, the railroads had such poor accounting systems that auditors found it virtually impossible to tell whether railroad companies were actually experiencing a profit or loss (Rubin, 1993). Consequently, in 1906, the Interstate Commerce Commission promulgated the Hepburn Act, which established uniform accounting principles for the railroads and other private sector organizations. Once this accounting system was imposed on private organizations, the federal government was pressured to adopt similar measures. This resulted in the Budget and Accounting Act of 1921.

Based on the recommendations of the Taft Commission on Economy and Efficiency, the Budget and Accounting Act required the President to submit an annual budget to the Congress, along with any other financial statements and data necessary to determine the financial condition of the government (Mosher, 1976). It also established the Bureau of the Budget, which was transferred to the Executive Branch in 1939. This Bureau was renamed the Office of Management and Budget in 1970, and now manages the yearly budget requirements. As a result, OMB is responsible for approving the pilot projects under GPRA (Panetta, 1994); and has ultimate responsibility for the implementation of the GPRA reform pro-

"As Rubin points out, the need for budget reform grew out of the need for clear financial reporting to provide greater public accountability of government funding."

cess. Therefore, under the umbrella of budget reform there has been an emphasis on financial responsibility and public accountability rather than political vision or adjustments in administrative management.

Lastly, the planning process itself found its beginnings in the tenets of military strategy and can be traced as far back in time as man has recorded. Whether one views the history of the Children of Is-

"... the planning process itself found its beginnings in the tenets of military strategy and can be traced as far back in time as man has recorded memory."

rael, the Greeks, the Romans, the Allied thrust in World War II, or more recently Desert Storm, one sees a series of battle plans and strategies followed with composite pre-

cision. It is not surprising, therefore, to see this same tenet carried into the management of corporations as the span of control became diffuse and complex, or to government management with its bureaucratic stratification. Only the manner and the context in which it has been applied has changed.

According to Bryson (1988, p. 22), "Strategic planning ... began as the art of the general." The word "strategic," as in strategic planning, is a derivative of the word "strategy" which in turn comes from the Greek word *strategos* (*stratos* [army] and *egos* [to lead]). A strategy, on the other hand, can be defined in two ways: it is a plan—"a direction, a guide or course of action into the future"—or it is a pattern—"consistency in behavior over time" (Mintzberg, 1994, p. 23). These two definitions are usually described as "intended"

strategy and "realized" strategy. In other words, what is intended is not always realized. Therefore, what happens in actual fact is "emergent" strategy. An effective strategy emerges from the ability to predict as well as react to unexpected events. Strategic planning, as it is mandated under GPRA, requires a recognition of the complex and dynamic environment of government. Consequently, it will drive implementers to outline broad targets, provide considerable flexibility to adapt to unexpected events.

The issues of efficiency and effectiveness have also been applied with different meanings in different contexts. While viewed one way at the writing of the Constitution, they are considered differently in a world of budget deficits, global competition, and mandatory taxation. Consequently, for purposes of GPRA, these concepts should be viewed within the precepts of the NPR. For it is the NPR that has captured GPRA as an outgrowth of its goals and ideals as a way of fashioning an efficient, effective government—one that "works better and costs less." How then is strategic planning within GPRA being implemented and what is its probability for success?

IMPLEMENTATION OF GPRA

The GPRA was first introduced in the Senate by Sen. William Roth in October 1990, as the Federal Standards and Goals Act; reintroduced after failure in 1991; retitled as GPRA and amended by Sen. John Glenn in 1992; reintroduced in January 1993 as the first piece of reinventing legislation addressed by the Administra-

tion and signed into law August that same year. Therefore, after a difficult political beginning, it is now being implemented. Ten pilot projects were approved in the first year and five times that number were added in the second. Yet it has not survived without problems. As Stephen Barr of the *Washington Post* noted in February 1994; "If all goes as planned over the next three years, OMB [will] learn how to link strategic planning to the budget, ... [but] for all the high-level attention, performance management remains one of the least understood administration initiatives."

To overcome some of these misunderstandings, John Koskinen (1994) issued a memorandum on Nov. 18, 1994, entitled "Requirement for Strategic Planning Under the Government Performance and Results Act." In this memorandum Koskinen addressed the importance of strategic planning as both the foundation and framework for implementation of all other parts of the Act and expressed OMB's intention to issue guidance in early 1995 on the development and submission of strategic plans. The first step was to establish a strategic planning task group to help prepare the guidance. Koskinen was particularly concerned with inter-agency, programmatic, and policy goals and was looking to this group and the President's Management Council to define the means and the responsibility for assuring "that goals are consistently and harmoniously reflected in individual agency plans." As an adjunct to the strategic planning task group, a task group was formed in November 1994 to consult with Congress in developing strategic plans and to participate in a Congressional coordination.

Direction submitted with the memorandum required that strategic planning be developed with Congressional consultation. Guidance on this activity was included in Circular A-11, Section 10.8, in September 1995 and then updated in Part 2, entitled "Preparation and Submission of Strategic Plans and Annual Performance Plans," in May 1997. Based on a collaborative effort of OMB, the Cabinet departments, and 20 independent agencies, the circular requires that "an agency strategic plan provides for aligning agency organization and budget structure with missions and objectives." It goes on to state that "These plans are a tool for agencies in setting priorities and allocating resources consistent with these priorities...." Part 2 of the same circular sets out more specific requirements for the submittal of each plan.

While an initial strategic plan must have been submitted by Sept. 30, 1997, and must cover a minimum of five years or longer, it is specifically noted that the plan is in fact only good for three years—after which it must be updated. This is to ensure that agencies are monitoring and adjusting their plans on a continuous basis. Agencies are strongly encouraged to submit a single agency plan, but if not, a stra-

"In this memorandum Koskinen addressed the importance of strategic planning as both the foundation and framework for implementation of all other parts of the Act and expressed OMB's intention to issue guidance in early 1995 on the development and submission of strategic plans."

tegic overview must be submitted that links the individual plans to the agency's missions and goals. The initial Annual Performance Plan must have been submitted to OMB in September of this year in support of the fiscal year 1999 budget.

Furthermore, agencies are required to document disagreement pertaining to agency goals. The transmittal letter should summarize dissenting views received from entities outside the Executive branch of government, the degree of disagreement, and the source(s). This will ensure that agencies are providing an opportunity for stakeholders to have a voice in the decision-making process. In addition, the completed strategic

"The complexity of government programs, divergent perspectives, and unclear missions and perspectives make it extremely difficult for decision makers to develop, understand, and interpret information reported results"

plan must be made available to the public at the same time it is transmitted to Congress—so that those same stakeholders have an opportunity to understand what is incorporated in the plan.

It is up to OMB to decide if the individual plan lacks required elements or is inconsistent with national policy and requires further work by the submitting agency. As part of a 1996 summer review, OMB provided internal guidance to OMB resource management offices to assist them in reviewing and consulting with the agencies under their purview. This guidance consisted of a set of questions to consider when guiding the implementation of the strategic planning process. Interagency clearance of a completed strategic plan is

now required at least 45 days before submission to Congress. Consequently, considerable guidance exists in the strategic planning area.

Of particular difficulty in the GPRA process has been the institution of measurement. The complexity of government programs, divergent perspectives, and unclear missions and perspectives make it extremely difficult for decision makers to develop, understand, and interpret information and reported results (Kravchuck and Schack, 1996). To assist in this process, OMB issued a "Primer on Performance Measurement" in February 1995. This primer is designed to assist the strategic planner in identifying and defining methods of measurement for their agency's activities. As such, it defines several performance measurement terms, outlines areas or functions where performance measurement may be difficult, and provides examples of different types of performance measures that can be used to ascertain performance outcomes. In addition, the Chief Financial Officers Council Report, in May of the same year, provided addresses and points of contact for assistance in implementing the process. The U.S. Army Corps of Engineers issued a "Performance Management Guidebook" in August 1995, which provides a performance measurement framework and a six-step development process for defining performance measurement in an operations and maintenance arena; and DoD issued an executive summary entitled "Key Criteria for Effective Measurement," in April 1996, defining the purpose, types, and requirements for performance measurement.

So what has been the progress to date? An initial report (in 1994) of existing pi-

lot programs by the National Academy of Public Administration highlighted several problems associated with the process. Primarily, performance plans did not tie performance to strategic planning. Neither did they contain clear statements of missions and goals. Specific recommendations were that Congress, program managers, and policy makers become real partners in GPRA's implementation to resolve issues associated with unclear agency missions. This included the cooperation of the committees that introduced GPRA to help to sell the effort to the two appropriation committees. In addition, the Academy suggested that agencies work hard to assure that performance plans at all levels relate to broader strategic thinking and mission accomplishments; that vision statements be less general and more useful in establishing specific objectives for management improvement; and that plans contain mission-oriented strategic thinking represented by the outcome indicators.

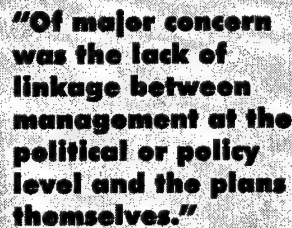
Of major concern was the lack of linkage between management at the political or policy level and the plans themselves. Part of this problem was viewed as stemming from the development of the plans at a very low level within the organization and consequently focused on a very limited set of work activities not specifically related to broader strategic thinking. It is clear from this report that agencies had not recognized the first principle of strategic planning, which is "to produce fundamental decisions and actions that shape and guide what an organization is, what it does, and why it does it" (Bryson, 1988). This requires the commitment and involvement of top key decision makers to bargain, negotiate, and coordinate the activities of affected parties (Bryson,

1988; Pfeiffer, 1991; Mintzberg, 1994).

The Chief Financial Officer's Council GPRA Subcommittee's report in January 1996 still reported the same basic problem. While performance planning had advanced substantially in some agencies, strategic plans were not driving the planning process. While agencies were aiming to develop a "single set of best measures," integration of various

initiatives was very difficult and organizational disconnects were impeding the process. Part of the problem, in their view, stemmed from the lack of incentives to do good program evaluations and the strong incentives to expand programs and missions. As a result, they recommended an in-depth review of programs and agencies that were providing credible performance planning. Based on this recommendation, OMB generated a call for lessons learned in recognition that agencies could benefit from careful analysis of the process and strategies that have evolved from pilot experiences. These lessons learned, combined with various GAO reports, are considered useful activities to understand and implement change.

The GAO has, in addition, completed a significant number of reports concerning agency strategic planning and other aspects of the statute, since the enactment of GPRA. These include reviews of activities associated with performance budgeting (GAO/AFMD 93-41), performance measuring (GAO 95-1, 95-187), management issues (GAO 95-22, 95-158),



"Of major concern was the lack of linkage between management at the political or policy level and the plans themselves."

changes associated with reorganization (GAO 95-166, 96-50), implementation status (GAO 95-130R, 95-167FS, 95-193), performance reporting (GAO 96-66R), and the role of the Congress (GAO 96-79).

"Along with these key steps, the report identifies eight management practices that are important to the success of any effort."

These reviews culminated in the publication of an executive guide entitled "Effectively Implementing the Government

Performance and Results Act," issued in June 1996. This guide identifies three key steps that are necessary for organizations to become more results-oriented. They are:

- Define mission and desired outcomes (strategic plans containing mission statements and outcome-related strategic goals).
- Measure performance (annual performance plans with annual performance goals).
- Use performance information (annual performance reports).

Along with these key steps, the report identifies eight management practices that are important to the success of any effort. They are:

- Involve stakeholders in the process.
- Perform an assessment of the environment (both external and internal).

- Align activities, core processes, and resources with the organizations mission.
- Produce a set of performance measures at each organizational level that demonstrates results, is limited to the vital few, responds to multiple priorities, and links to responsible programs.
- Collect sufficiently complete, accurate, and consistent data.
- Identify performance gaps.
- Report performance information.
- Most importantly, use performance information to support the mission of the organization.

The GAO recognizes that these steps and practices by themselves cannot ensure the success of the organization. Leadership practices must reinforce GPRA implementation and a results-oriented management. These practices include:

- devolving decision making authority within a framework of mission-oriented processes in exchange for accountability for results;
- creating incentives to encourage a focus on outcomes;
- building expertise in the necessary skills needed to perform strategic planning, performance measurement, and the use of performance information in decision making; and

- integrating management reforms—existing planning, budgeting, program evaluation, and fiscal accountability processes with GPRA requirements to ensure consistency while reducing duplication of effort.

Once in place, the GAO suggests that these key steps and management practices form the framework for a GPRA results-oriented management culture. It is interesting to note that although the GAO recommends the inclusion of stakeholders, there is no recommendation for collaborative leadership or teamwork as a desired practice for GPRA implementation.

Other reports issued since the Executive Guide have focused more on areas of significant concern—for example, managerial accountability and flexibility progress (GAO/GGD-97-36), Congressional and Executive branch decision making (GAO/T-GGD-97-43), performance budgeting insights (GAO/AIMD-97-46), and key questions to facilitate Congressional review (GAO/GGD-10.1.16). Therefore, while GPRA's implementation is progressing, significant learning is still considered necessary. What then are some potential consequences of the Act for DoD? The Planning, Programming, Budgeting System (PPBS) was instituted within the Department of Defense by McNamara in the 1960s. This system requires the formulation of government objectives, like GPRA. It relates outputs to program inputs (unfavorable impacts). It puts values on inputs and outputs; aggregates the outputs into total benefits; aggregates the inputs into total costs; identifies the differences; considers existing as well as alternative strategies of action, and develops a budget based on the outcomes

of these choices (Mintzberg, 1994). The differences between this system and GPRA seem to lie in the inclusion of stakeholder discussions, the discussions with Congress, and a stronger emphasis on "performance outcomes" as opposed to "outputs." Outputs are seen as a

measure of the use of resources, while performance outcomes define the success of the programs. Therefore, DoD established the GPRA working group to study ways to refine PPBS to meet GPRA legal requirements and to strengthen internal management processes.

The 1993 Bottom-Up Review, as updated by the National Security Strategy (President) and the National Military Strategy (JCS), served as the DoD strategic plan until completion of the Quadrennial Defense Review on May 19, 1997. This document superseded the Bottom-Up Review. The Quadrennial Review now serves as the DoD strategic planning document under GPRA. The DoD vision and mission statement were published in the 1997 Defense Planning Guidance and appear in the GPRA Annex of that document (see Figure 1) (Maroni, 1996). A set of general goals and objectives derived from the Quadrennial Review and also published in the Defense Planning Guidance are currently being refined within DoD for the fiscal year 1999 submission to Congress. In addition, the Office of Analysis

"It is interesting to note that although the GAO recommends the inclusion of stakeholders, there is no recommendation for collaborative leadership or teamwork as a desired practice for GPRA implementation."

DoD MISSION STATEMENT

The mission of the Department of Defense is to support and defend the Constitution of the United States, to provide for the common defense of the United States, its citizens and its allies, and to protect and advance U.S. interests around the world.

DoD VISION STATEMENT

The Department of Defense:

- fields the best trained, best equipped, best prepared joint fighting force in the world;
- supports alliance and security relationships that protect and advance U.S. security interests;
- advances national interests by working effectively with other agencies, Congress, and the private sector; and
- serves as a model of effective, efficient, and innovative management and leadership.

Figure 1. DoD Mission and Vision Statements

and Evaluation, OSD(PA&E) issued guidance to DoD Components as follows:

The Chairman, Program Review Group, will establish a team led by OSD(PA&E), to assess the performance of the DoD Components, with respect to the DoD Corporate Goals that are to appear in the Defense Guidance. The Component POM submissions will be used as the basis for this assessment. The outcome of the assessment will be reported at the end of the program review. In addition, the team may also review performance measures for use in GPRA activities subsequent to this program review.

DoD anticipates that the fiscal year 1999–2004 PPBS cycle will contain all the elements of GPRA. The first Annual Performance Plan, which will include performance measurement criteria, will be submitted as part of the fiscal year 1999 President's Budget. Consequently, DoD is well on its way to integrating GPRA into the PPBS budgeting process.

Nevertheless, the GPRA is still problematic. Organizations most advanced in GPRA say "it is turning us upside down" (Laurent, 1996). Since GPRA requires a cultural change as it attempts to blend accountability with entrepreneurship. There has yet to be a recognition in some agencies that there is no risk without failure (Groszyk, 1995). Similarly, measuring performance can become a meaningless,

sterile, statistical exercise, if managers are not trained and empowered to promote change and incorporate performance-based management into daily practice (Laurent, 1996), or if they do not understand or take into account the limitations of performance measurement systems (Kravchuk and Schak, 1996). Measures should not become a substitute for effective ongoing program management, but meaningful incentives for managers to change how they manage and become more accountable (Groszyk, 1995). This will require the inclusion of customers and stakeholders in the validation process (Mihm, 1995–1996). Meanwhile, managers who can master this process and show the positive outcomes of their program's efforts will have a clear advantage obtaining or retaining program funding (Mihm, 1995–1996).

Early assessments indicate that agencies are still having difficulty describing the relationship between long-term goals and annual performance goals and are just beginning to look at enhancing inter-agency coordination for programs that are "cross-cutting" in nature (Raines, 1997). OMB has also noted that a review of performance goals is on-going and that consensus on these goals still needs to be reached (Koskinen, 1997). As Acting Comptroller General of the United States James F. Hinchman noted (1997), "... improving management in the federal sector will be no easy task, but GPRA can assist in accomplishing it."

Even given that these hurdles are breached, can the agencies under GPRA establish a system flexible enough to counter budget turbulence with sufficient viable contingency plans to meet legislative goals (i.e., program success)? There

is still some concern that legislators are lagging in their understanding of GPRA and their role in its promotion (Laurent, 1996). As reports become available to the public, accountability and performance of the administration and Congress will become very visible (Groszyk, 1995). Both will be very hard pressed to fund programs that cannot convincingly show that outcomes are achieved (Mihm, 1995–1996). Conversely, a lack of Congressional interest is likely to be fatal (Groszyk, 1995). House

Majority Leader Rep. Dick Armey, speaking before the House Government Reform and Oversight Committee in February 1997, urged both Democrats and Republicans to become knowledgeable and to "... show a willingness to reexamine pet projects with an ear toward objective credible information about the results of these programs." It will be interesting to see if members of Congress, once they have the necessary information, will be able to make hard choices; or if they will use it to increase their level of oversight to control administrative action. GPRA could stand in stark contrast to the implementation of the National Performance Review and in turn, could create conflicting administrative requirements (Winchell, 1996). In any case, GPRA will only be successful if it becomes part of the principles and practice of everyday managerial routines

"... measuring performance can become a meaningless, sterile, statistical exercise, if managers are not trained and empowered to promote change and incorporate performance-based management into daily practice."

(Groszyk, 1995). Only the future will show if GPRA will result in any real changes becoming embedded in our culture. As OSD Comptroller John J. Hambre stated in 1993, it should "... be more than

another layer of reporting, the process must be integrated with and reflect the expectations of [the] planning and budgetary process."

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A THEORETICAL CONSIDERATION OF ACQUISITION REFORM

Dr. Deborah F. Frank

The federal government acquisition process is continually changing. It responds to constant shifts in national and international situations. Culver, in *Federal Government Procurement—An Uncharted Course Through Turbulent Waters*, gives a historical perspective of the U.S. procurement process, from colonial times onward (1985). It reflects continual turbulence and attempts to adapt to a changing environment. Placed in historical perspective, today's reforms continue the trends of the past 220 years.

Acquisition reform is today's hot topic. It's the latest effort to improve the acquisition system. But before we reform it, we must first understand why we are doing so. What are the objectives? Reform for whose purposes? Who are the reforms for? Whose needs does the system currently meet and hope to meet? What realistic alternatives exist? In his remarks to the Industrial College of the Armed Forces, Paul G. Kaminski stated that acquisition reform ought to make us more efficient, improve our business practices, and allow us to buy more with less (1995).

In this reform process, we must remember the forces that drive the current state of acquisition: protect military uses against poor workmanship, protect the public against fraud and abuse, and advance certain socioeconomic goals. Given the objective of acquisition reform and the forces that drive the acquisition process, it is no wonder the reform effort evokes such discussion, analysis, and review.

May you live in interesting times.

—Chinese benediction

We are in a time of reform. Private industry has been thrust into a global marketplace that demands maximum efficiency. This need for efficiency has resulted in a recognition and

embrace of attempts to maximize productivity. In this regard, reengineering has emerged as a highly successful procedure to maximize organizational productivity.

In "Acquisition Reform: A Mandate for Change," former Secretary of Defense William Perry (1994) concludes "... DoD has been able to develop and acquire the best weapons and support systems in the world. DoD and contractor personnel accomplished this feat not because of the (acquisition) system, but in spite of it. And they did so at a price ... the nation can no longer afford to pay...."

Recommendations for the reform of the government's acquisition process are generally directed at specific elements within the system (i.e., numbers of workers, dollar threshold for contracting, use of standard items). This attempt at reform of isolated elements will improve the acquisition system, to some extent. Yet a look at other organizations' attempts at reform reflects a different approach. Although the government is seriously pursuing acquisition reform, when compared to other organizational streamlining efforts, its approach appears limited in scope.

The current government acquisition reform effort seems to model the industrial sector effort via the use of reengineering. But if we consider the federal acquisition process against a theoretical construct of systems theory, we can establish that factors and influences exist for government that are absent in the industrial sector. These factors may explain two things: why reengineering is not working as quickly in government as in industry, and why the continual parade of

acquisition reform efforts over time has failed to "reform."

This article looks at the current acquisition reform effort. We'll consider the influence of the industrial reengineering movement in terms of the attempt to apply that process to government acquisition. The entire process will be viewed against a construct of system theory to assess influences that might exist beyond the reaches of the current acquisition effort.

PLAY IT AGAIN, SAM

The Military Acquisition Subcommittee meets this morning to begin a series of hearings on acquisition policy and reform and ... whether we can really do it at this time. One could argue we have been attempting to reform the acquisition system for decades, dating all the way back to the Hoover Commission on up to the Packard Commission and the Defense Management Review. I am encouraged that we may have an opportunity that we never had before.

—U.S. Congress (1994), p. 1

The U.S. acquisition system has been burdened with many obvious criticisms for years. There are the routinely quoted

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problems of contractor overpricing for simple items. There is the common perception by Americans that "the government" does things the hard way. There are also the more obvious signs that reflect a concern with the U.S. acquisition system. The Comptroller General report, "Weapons Acquisition: A Rare Opportunity for Lasting Change," verifies that almost continual taskings of commissions and task forces are examining the system to determine problems and recommended solutions (Comptroller General, 1990).

The National Performance Review began in 1993 when President Bill Clinton announced a six-month review of the federal government. The Report of the National Performance Review documented a process that was intended to change federal government operations. The process followed a logical sequence of cutting red tape, putting customers first, empowering employees, and getting back to basics. This reform effort has taken on the mantle of reengineering, with the intent of assess-

ing current acquisition processes and seeking more effective, efficient ways of doing business.

Reform is not a new word in the Department of Defense (DoD) vocabulary. Since the 1950s acquisition reform has been attempted, without much success. The reform efforts of the sixties were initiated by Robert McNamara in an attempt to "fix" the procurement system. Table 1 shows there has been a series of reforms since then (McNaugher, 1990).

Reforms have addressed such issues as better planning, increased centralization, simplified reporting chain, better cost estimates, additional executive-level personnel, inclusion of the Joint Chiefs of Staff, increased milestone approvals, and funding and program stability.¹ Yet the system resists significant change. The evolution of the "acquisition reform waterfall" results from the lack of success. Why is there a continual parade of reform initiatives? Each of these initiatives has championed sound management, but failed to recog-

Year	Initiative
1961	McNamara initiatives
1970	Fitzhugh Commission
1972	Commission on Government Procurement
1976	OMB Circular A-109
1978	Defense Science Board Acquisition Cycle Study
1979	Defense Resources Management Study
1981	Defense Acquisition Improvement Program
1983	Grace Commission
1986	Packard Commission
1986	Goldwater Nichols
1989	Defense Management Review

Table 1. Reform Initiatives

nize the existence of the "acquisition culture," the environment in which all of the participants operate (McNaugher, 1990, p. 188):

Reformers have spent a good deal of time and effort since the 1950s trying to centralize, simplify, and stabilize the weapons acquisition process. Yet the process somehow defies centralization and stabilization, and if anything it grows more rather than less complicated ... An important part of the problem can be attributed to the political milieu in which reform occurs.

The repudiation of past reform efforts does not end there (Gregory, 1989, p. xii):

Reform of weapon-acquisition systems has produced precious little by way of improvement. Incessant finger pointing, second-guessing, scandal brandishing, regulation writing, and general viewing with alarm have produced an atmosphere of distrust—hardly conducive to getting the job done....

Finally, a 1986 survey by Arthur D. Little reported that there is a perception that the acquisition process is so cumbersome that it is unlikely that it can ever function in its present form. It is beyond repair in its present state. To succeed, the reformers must not only recognize this culture, but also have the ability to effect change. Despite commissions and Congressional interest and continual DoD directives and changes, the U.S. acquisition

system continues to function under a heavy burden of regulation and bureaucratic inefficiencies.²

Past reform efforts were instituted on a regular basis. Each of the efforts resulted in additional recommendations, regulations, and personnel. The President's Blue Ribbon Commission on Defense Management recognized this problem (Gansler, 1991, p. 14):

In general we discovered these problems [acquisition inefficiencies] were seldom the result of fraud or dishonesty. Rather they were symptomatic of the underlying problems that affect the entire acquisition system. Ironically, actions being prescribed in law and regulation to correct [the problems] tend to exacerbate the underlying issues by making acquisition procedures even more inflexible and by removing whatever motivation exists for the exercise of individual judgment.

Yet the reform parade continues. Evidently the results of the reform efforts have not effected significant or lasting or effective or desirable change. Some point is being missed, the source of the problem is not being addressed, the "easy" solutions are being implemented. Or the real problem is not identified.

The problem must be identified and analyzed in a different fashion. To effect change of a process, to alter the output of product, we must identify the inputs to that process. By identifying inputs, the makeup of the process can be clearly analyzed and a better understanding of its rationale can be developed. This identification, once

done, can suggest which inputs should be changed or if they can be changed. Without assessing inputs that make up an output, the process cannot change.

CHANGE

The only people who like change are wet babies.

—Sir Brian Wolfson

The federal government is not the only institution seeking answers on how best to change. American companies constantly search for ways to improve their operations. Surveys suggest that companies are constantly undertaking programs, initiatives, or projects to improve organizational performance. Of 200 companies in a recent survey, 42% initiated 11 or more projects within the past five years (*Management Review*, Spitzer and Tobia, 1994). This validates the premise that companies are willing to undergo the turbulence of change in search of improved performance, profits, and worker motivation.

Firms create advantage by discovering new and better ways to compete in the industry and bring it to market. This represents innovation, including improvements in technology and better ways of doing things. It is reflected in product and process change, new approaches to marketing, and new forms of distribution. This change is based more on an accumulation of small insights than on technological breakthroughs.

Change is difficult. In a corporation there will be any number of "customers" who will resist the change. Many parties—

stockholders, the board of directors, vendors, management, public relations—have a vested interest in maintaining the system as it is, for any number of reasons. Manganelli and Klein (1994) maintain that change within an organization must be mandated by senior management, at the least, and "worked" with the customers, at least those maintaining power within the organization. They, like Hammer and Champy (1993), also stress the "rapid" and "radical" approach to business reengineering. They assert that anything less will result in failed improvement programs.

A THEORETICAL CONSIDERATION

An analysis of this subject must be based on an understanding of a theory that is applicable to its structure, process, or operational mode. This allows us to appreciate the current situation, variables that may influence the subject, and we may have the basis for some projections. To logically analyze a system or process, it must be placed against a theoretical framework. In this fashion, aspects of operational system can be more thoroughly studied and projections can be made based on definable data.

I believe that a theoretical assessment of a problem is necessary before one can propose effective alternative solutions. A look at the current acquisition process against a theoretical framework will help us understand process flow and give us an opportunity to consider possible inputs and outputs. We will therefore have a better understanding of the forces that drive a process, and in turn, the results of that process.

SYSTEMS APPROACH (WHAT GOES IN MUST COME OUT)

The system theory is a rather basic process presuming that, with certain input, there is a certain, predictable output. The same input will continue to result in the same output unless there is some disruption to the process. That is, unless other inputs change or interact in a different fashion.

Beishon and Peters state that "the systems approach has been adopted by social psychologists as a basis for studying organizations." According to these authors, there is an increasing trend in adapting the systems approach to organizational theory and management practices. This

"The system theory is a rather basic process presuming that, with certain input, there is a certain, predictable output."

adaptation does not purport to display an exhaustive analysis of the management practice; rather, it provides an illustration that

will assist in analysis and evaluation.

Emery (1969) states that "the essential characteristic of a system is that it is composed of interacting parts, each of which has interest in its own right." This is the key to the systems theory and the key to this analysis on acquisition reform. Emery continues that the interacting parts are the significant factor in this theory and influence the behavior of the system. A given system component transforms inputs into outputs, presumably contributing to the accomplishment of a desired purpose of the system.

What are the inputs to our acquisition system? Can we define the elements that

make the U.S. acquisition system unique? In the quest for more efficiency, other countries have assessed inputs to their acquisition systems and altered inputs as necessary. Houston (1994) states that these efforts have resulted in more efficient and effective acquisition processes. These studies focus on government control, budgetary process, workforce training, relationships with contractors, and legislative oversight. These factors are some of the key drivers in the definition of a unique acquisition system.

The Comptroller General report (1990) concludes that an "acquisition culture" exists throughout DoD.

This culture can be defined as behavior ... of participants in the acquisition process DoD and Congress—and forces motivating behavior. The process is an interaction of participants rather than methodological procedure.

Given this acquisition culture, participants operate within its formal and informal rules and expectations. Roles and rules are defined; the importance of winning is understood. Program survival is intertwined with participants' needs—all participants. These include the military services and the Office of the Secretary of Defense (OSD), which feel a need to perpetuate a mission; contractors, who want to sustain business and acquire profits; overseeing organizations, which want to find and fix problems; Congress, which needs to satisfy the public (and individual members, their constituencies); and program managers, who want to maintain or enhance their reputations. To further complicate the culture, the short-term involve-

ment of many participants encourages short-term payoffs.

The integrated management framework is an interchange of the three functions of budgeting, acquisition, and requirements. These functions give customers from different arenas (Congress, the services, regulatory agencies, and OSD) an opportunity to play in the acquisition process. Each player brings his own agenda and has the power to influence the operation of the acquisition. Our acquisition system reflects the government and political systems in which it exists.

All systems have certain inputs that contribute to the peculiar system that results. These inputs include such diverse elements as cultural expectations, regulatory requirements, customers and stakeholders, budgetary processes, and political pressures. I will explore the U.S. acquisition system in light of a systems theory, which will shed light on its strengths and weaknesses, and help define the parameters that must be considered in acquisition reform.

Given a systems theory and a general understanding of the key factors (inputs) in an acquisition system, what now? If we are so anxious to improve our acquisition system, a serious effort can be made to adjust input and environment to create a more efficient, effective organization.

THE SYSTEM WORKS !

The problem is, simply, that the current acquisition system works. Given a parochial view of the acquisition system in terms of efficiency and effectiveness, it certainly has its problems. This is routinely recognized and documented; there is no

need to pursue that avenue here. But when viewed from the larger perspective, and when one considers the many players in the acquisition process, the system is successful for the customers. Significant changes will affect these players (who have considerable power), and they may be reluctant to embrace another system.

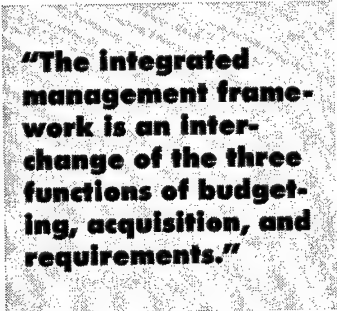
The "success" of the system is well documented. Some express concerns that certain customers, small businesses, minority contractors, and suppliers profit from the current system, and thus may attempt to derail efforts at acquisition reform.

But the point here is not limited to profiteering. These players, as well as many others, have established themselves in an ac-

quisition system that provides status, power, influence, and opportunities for success, as well as financial rewards. The system works for them and they will resist change that alters this type of return.

Forman puts forth an interesting proposition in "Wanted: A Constituency for Acquisition Reform" (1994). She asserts that there are continuing calls for reform from all arenas; all parties agree that the acquisition process is inefficient. But the reason our system has not been changed is because the system is working the way its customers want it to.

The military are the most visible customers. Given the current system, their influence and power are allowed to expand. Each service controls its own destiny by controlling its own acquisition. Defense contractors are also very inter-



"The integrated management framework is an interchange of the three functions of budgeting, acquisition, and requirements."

ested in maintaining a system in which they can sustain operations as well as make profits. Any changes in the acquisition system may modify this capability. Another customer is the Congress. Given the current process, members of Congress can influence military acquisition programs and provide jobs for their states' citizens. Additionally, they may appear in the role of reformer in their efforts to "clean up the system." The media also benefits from the current system by grandstanding any actual or perceived problem in the system, alerting the public to fraud, waste, and abuse. Small business is also comfortable with the system in its assurance of continuing awards for their markets.

Considering these inputs to our acquisition system, one can see that the call for

"A larger, more potent factor emerges that influences, indeed controls, the acquisition process—politics."

reform must be supported by a diversity of customers so as to overcome these vested interests. Forman maintains that any change to the

acquisition process must overcome these entrenched areas first. Acquisition reform advocates also recognize this dilemma. Many authors have expressed concern regarding the entrenched interests of special interests such as small business, minority contractors, suppliers, media and others that profit from the current system.

A recent Government Accounting Office (GAO) report suggests that acquisition funds are among the most discretionary in the DoD budget. This sole factor must make these funds particularly appealing to politicians, whose existence is determined by constituents, and whose elec-

tions are supported by powerful lobbyists and political action committees, which often represent defense contractors. This relationship involves politicians in the acquisition process. Add to that formula the distasteful downsizing and decrease of the defense budget—where more hands chase fewer dollars.

POLITICS

In the above discussion it becomes apparent that inputs to the acquisition process cannot be readily changed. The process is meeting the needs of those involved. A larger, more potent factor emerges that influences, indeed controls, the acquisition process—politics. This author believes that the political environment is a critical factor in the acquisition process. To modify the defense acquisition process, one must consider the role of politics. An attempt to influence the current process without assessing political influence will fail.

Political involvement in the acquisition process began 220 years ago. Congress received virtually every power over the budget via Article I of the Constitution. Since that beginning, the involvement of Congress within the DoD budgeting and acquisition cycle has increased.³ The result of this evolution is that Congress is increasingly involved in defense budget details. In the period from 1980 to 1990, the number of line item changes made by Congress in the Defense budget rose from 1,500 to more than 2,500. The effect of this degree of micromanagement is that Congress decides what programs are killed, supported, or modified. This feeds the Congressional need to "feed" its con-

stituents. A telling comment by a member of Congress summed up the acquisition reform problem. "We can't reform the Pentagon until we reform ourselves."⁴

The increasing degree of political involvement is obvious in the changes to the DoD budget request between funding requested by the military and the amounts appropriated by Congress (Table 2) (Comptroller General, 1990). This requirement for increased visibility demonstrates the ever-growing interest and involvement of the political system in the federal acquisition process. By maintaining visibility, Congress can more easily influence, and possibly control, decision making and funding distribution (Adelman and Augustine, 1990).⁵

A recent example of the political influence on the acquisition process is reflected in the reform process itself. DoD designed a far-reaching acquisition reform proposal. Although it reflected an ambitious effort for acquisition reform, it attempted to eliminate too much (politically) in the way of social regulation. This proved to be politically unacceptable. An acquisition reform bill was passed, but it was not as

ambitious as the proposal supported by DoD.

Another significant political influence on the acquisition process is the Defense budget. The current decreasing trend in the size of the budget suggests that congressional representatives will attempt to maintain or even increase their influence over the acquisition process. The significant changes in the budget are reflected in Table 3 (Schick, 1995).

These Congressional issues affect the defense acquisition process. Intervention by the legislative and executive branches of the government may meet their needs—political, economic, or social—but the result for the acquisition process is constant turbulence. This turbulence is a critical factor in decreasing the management capabilities at the appropriate levels. This in turn feeds the perception that program managers cannot manage their programs, in turn feeding the perception that higher level managerial "help" is needed. Norm Augustine contends that "turbulence in the defense acquisition management process must be eliminated" (Adelman and Augustine, 1990).

Year	Auth	Appro	Total
1980	300	1200	1500
1982	350	1200	1550
1984	900	1500	2400
1986	1350	1800	3150
1988	1250	1700	2950
1990	1150	1350	2500

Source: Comptroller General of the United States (1990).

Table 2. Congressional Changes to DoD Budget Request

Year	Outlay FY87\$ (B)	Percent Change	Defense Percent
1960	220		52
1965	204	-7	43
1970	263	29	42
1975	184	-30	26
1980	187	2	23
1985	261	40	27
1990	273	5	24
1995	207	-24	18
1999*	175	-16	14
*Projected Source: Schick, A. (1995).			

Table 3. Defense Outlays and Percentage of Total Outlay

The ever-increasing Congressional interest in terms of micro-management, budget, and political concerns remains a growing issue. This Congressional oversight is a critical input in the acquisition process. This influence affects and in some respects controls the acquisition process. This micromanagement is increasing while calls for acquisition reform and simplification and reengineering continue; but increasing Congressional management and acquisition reform are irreconcilable goals.

In a consideration of the systems theory applied to the acquisition process, political interests are a major input. The political influence affects the acquisition process. This political input affects all activity and introduces a culture that must be understood to appreciate the acquisition process. The system cannot be changed unless the inputs are changed.

Obviously some of the inputs into the system are more influential than others. Based on the power of political input—its control of regulation, budget, reporting, and approval—it is the most influential in shaping the acquisition process. Any reform of this acquisition process should consider this input and acknowledge its influence of the system.

Our political system is structured so that competing branches of government intersect with one another. Originally instituted as a system of checks and balances, these branches of government hamper efficiency and reform. Managerial reform efforts are complicated, and possibly convoluted, by the interaction of the political system. So any attempt for centralization within one branch of the government is fought by one of the other branches. Similarly, any reform effort to minimize political influence in the acquisition system

will be fought by the branches of the government.

The costs of politicization have been high. Increasingly dominated by the short-term perspective of the political process, the acquisition process makes basic mistakes in the allocation of resources to research and development, where a long-term perspective is required. increasingly dominated by the pork-barrel decision rules of American politics ... where flexibility and decisiveness are required.

McNaugher (1989, p. 15) goes on to assert that "effective reform would require fundamental change in the relationship between the political system and the acquisition process."

REFORMING THE REFORM PROCESS

Osborne and Gaebler (1992) say that, to reinvent government, the incentives that drive public institutions must be changed. An analysis must be performed on the institution to assess what elements of the market need to be improved to make it work.

Political influence must be acknowledged in the acquisition reform process. Politics is the environment within which the process functions. Unless the political influence is acknowledged, no significant, lasting change can be made. This includes Congressional interest of all types, budget controls, reporting requirements, constituent interest, and contractor interest. These are powerful influences.

The United States could also modify its acquisition system. But any modification, however small or large, would require the support and approval of the "customers" who provide the input to the process. The change will be neither easy nor comfortable for the parties involved. Reform would require a change in the inputs to the acquisition process; a change in the relationship between customers and the acquisition process. Most significantly, reform would require a change in the relationship between the political system and the acquisition process.

The critical change would be the political dimension. Intensive Congressional micromanagement influences the federal acquisition process. This control causes delay and risk-averse actions on the part of those who are responsible—the program managers.

Gregory (1989) discusses this increased involvement by Congress. He says that the role of Congress should be that of a board of directors, not managers. But Congress has become so involved in the

"Political influence must be acknowledged in the acquisition reform process."

acquisition process that it has lost its objectivity as a reviewing authority. Until Congress recognizes this conflict and removes itself from acquisition management, the problem will continue. Thus, this one significant input into the acquisition system will continue making real reform impossible.

There appears to be a consensus that the acquisition reform process must address all factors influencing the output. Additionally, one must face the political

environment that so heavily influences the acquisition process. If changes are not made to the political aspect, then, based on the history of acquisition reform, we can probably assume that changes made to other inputs will result in a marginal return. Corporate America has effectively used the reengineering process to introduce needed innovations. But reengineering has the ability to effect change to all necessary inputs in the corporate world. I do not believe this to be true in the federal acquisition process. Politics cannot be ignored as a critical factor in the acquisition game. The theoretical structure of the system, with its second- and third-order effects, must be recognized before any meaningful change can take place. McNaugher (1989, p. 86) reaches this same conclusion.

It remains to be seen whether some reforms might succeed where others so far have failed. Clearly, however, far more radical reorganization is in order, a reorganization that basically alters the relationship between the political system and the acquisition process. As troubled as politicians may be by features of the acquisition process, the political system as a whole has so far been unwilling to contemplate change this great. Reluctance is not surprising; a political system accustomed to muddling through will probably engage in radical reform only in response to massive failure. And the fact is, the failures of the acquisition process tend to appear on the margins.

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ENDNOTES

1. In 1985, in response to media accounts of fraud, waste, and abuse, the President established the Blue Ribbon Commission on Defense Management. The major recommendations of the commission were: the establishment of an Under Secretary of Defense for Acquisition, the establishment of a service acquisition executive for each service, and the appointment of program executive officers. All recommendations were aimed at DoD's management policies and procedures.
2. McNaugher discusses, in detail, reform attempts since McNamara. In summary, the results of reform have led to an imposition of political values on the weapons development process. He concludes that reform efforts have been counterproductive.
3. Shilman (1988) discusses the history of the Congressional budget process, its evolution, and current status.
4. Wildavsky (1987) reviews the current Congressional committee structure and discusses how this structure contributes even further to the involvement of Congress in the DoD budget and acquisition process.
5. Adelman and Augustine discuss the defense procurement mess that results from Congressional micromanagement. They provide examples that show this to be an increasing trend.

THE DEFENSE ACQUISITION WORKFORCE IMPROVEMENT ACT: FIVE YEARS LATER

***Andrea Garcia, Hugo Keyner, Thomas J. Robillard,
and Mary VanMullekom***

DAWIA was enacted five years ago, and the following selective assessment finds that progress has been made. The authors review the changes made to achieve the goals outlined in the legislation, and focus on several areas that remain to be addressed, in order to carry out the intent of the law.

The Defense Acquisition Workforce Improvement Act (DAWIA), Public Law 101-510, Title 10 U.S.C.¹, was enacted to improve the effectiveness of the personnel who manage and implement defense acquisition programs. As part of the fiscal year 1991 Defense Authorization Act, it called for establishing an Acquisition Corps and professionalizing the acquisition workforce through education, training, and work experience. While the Act applied to both civilian and military personnel, it emphasized the need to offer civilians greater opportunities for professional development and advancement.

This study examines the state of defense acquisition workforce management five years after the law was enacted. We will not provide a comprehensive review of DAWIA implementation throughout

the entire Department of Defense (DoD), but will instead focus on selected areas. We look across military departments and defense agencies to compare and contrast their policies and procedures regarding how they manage their acquisition workforce. The primary focus is on issues pertaining to civilians, since they make up the majority of the defense acquisition workforce and are a special emphasis area in DAWIA.

We found much progress has been made over the past five years, and the DoD Components² have achieved significant gains in improving the quality of their acquisition workforce. But more remains to be done. Our analysis shows that two main areas need improvement: diversity of policies and practices, and disparity between civilian and military opportuni-

ties. This paper provides data to support these two findings and offers some strategies to overcome them.

DIVERSITY OF POLICY AND PRACTICE

DAWIA expressly calls for uniformity in implementation throughout the Department of Defense.³ In general, DoD Components have been consistent in their compliance with the major provisions of the law. For example, each has established an acquisition corps, identified critical acquisition positions, and enhanced professional development of its acquisition personnel through education, training, and work experience. Each has appointed a director for acquisition career management (DACM) to manage the acquisition

workforce,⁴ and each has established management information systems to track demographics, training, career progression, and other variables. In addition, each component has reduced turnover of incumbents in senior acquisition positions, increased representation of civilians in some senior acquisition positions, and developed procedures to provide for the selection of best qualified individuals.

In short, all have complied with the broad requirements of DAWIA. But when one looks at the specific policies and practices of each DoD Component, there is considerable variation between them. We found the Components differ in their Acquisition Corps membership criteria, mobility requirements, and centralized referral systems. The differences are described in the following paragraphs.

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ELIGIBILITY CRITERIA FOR ACQUISITION CORPS MEMBERSHIP

DAWIA calls for each military department to establish an Acquisition Corps and specifies eligibility criteria for membership. According to the law, Acquisition Corps membership is limited to civilians holding positions at GS-13 or above and military at the rank of major/lieutenant commander or above. In addition, membership is limited to persons having a college degree, with at least 24 semester credit hours of business management, and at least four years of acquisition work experience. Military departments are allowed to grant waivers to these provisions and to impose additional eligibility requirements.⁶

In addition to establishing standards and developing skills for acquisition professionals, DAWIA was intended to ensure that the best qualified people were selected for acquisition positions.⁷ What approach does each department take to ensure the "best qualified individual" is selected for a vacant acquisition position? Each department has published literature covering the DAWIA criteria for staffing and training purposes. In the Department of the Navy (DoN), for example, all civilian Critical Acquisition Positions (CAPS) must be advertised at least within the department and must include DAWIA criteria (i.e. Acquisition Professional Community⁸ criteria) in the rating and ranking of candidates. The rating and ranking, of course, is based (among other things) on whether an individual is certified as an acquisition professional and the level of certification he or she possesses. And, yes, all Defense Components recognize DoN certification, just as DoN rec-

ognizes certification granted by the Army, Air Force, and other DoD Components.⁹ If that is the case, and there is full reciprocity between them, are certification requirements and criteria uniform across the DoD Components? Not exactly!

DoD Components have established generally similar requirements for Acquisition Corps membership. All comply with the law and follow the education, training, and experience requirements contained in DoD Manual 50G0.52M for certification at basic, intermediate, and advanced levels (Levels I, II and III). Components vary, however, in some policies regarding Acquisition Corps membership for civilian personnel.

First, the Navy more narrowly defines its Acquisition Professional Community than the other services. For example, only select portions of the Comptroller career field are APC members: business and financial managers in program management offices, cost estimators in systems commands, and cost schedule control performance evaluators.

Another difference is the requirement for incumbency in an acquisition position. As a general rule, the Army and Navy require that civilians be in designated acquisition positions when applying for membership in the Acquisition Corps. Thus, they normally do not certify an individual who is not occupying an acqui-

"In addition to establishing standards and developing skills for acquisition professionals, DAWIA was intended to ensure that the best qualified people were selected for acquisition positions."

sition billet, regardless of his or her professional qualifications. Consequently, personnel who otherwise meet the qualifications for certification are excluded from competing for critical acquisition positions. The Air Force, on the other hand, will certify anyone who possesses the necessary education, training, and experience, regardless of his or her current position.

In sum, the Components have imposed different criteria for Acquisition Corps

"In sum, the Components have imposed different criteria for Acquisition Corps membership, and in some cases they restrict membership to those who are currently in acquisition billets."

membership, and in some cases they restrict membership to those who are currently in acquisition billets. Did the lawmakers intend to ensure the availability of a

ready pool containing the greatest possible number of "best qualified" potential candidates, or did they intend certification of only those civilians currently occupying acquisition billets? We believe Air Force policy is more consistent with the intent of DAWIA because it maximizes the number of truly qualified people who can be considered to fill vacant acquisition positions. The fact that someone is not currently holding an acquisition position does not diminish his or her education, skill, knowledge, or background. Moreover, military personnel are not subjected to this criteria. In all services, once an officer is certified as an acquisition professional, he or she continues to possess this military occupational specialty (MOS) whether or not the individual's current assignment is

designated as an acquisition billet. Thus all personnel, both military and civilian, should be eligible for acquisition corps membership based on qualifications, not on a job description or current assignment.

CIVILIAN MOBILITY

DAWIA encourages the Components to promote mobility of civilian Acquisition Corps members. It authorizes the Secretary of Defense to require civilians to sign mobility statements, and it requires him to identify categories of civilians who, as a condition of serving in the Acquisition Corps, must sign mobility statements. This authority has been delegated to each of the Defense Components.¹⁰

Should civilians be required to be geographically mobile? This is another area where DoD Components agree to disagree. The law is vague as to what exactly is meant by "mobility," and the Components interpret it differently. There are at least three different definitions:

- Functional mobility is a new assignment within the same organization and commuting area, but to a position in another career field or functional area or specialty.
- Organizational mobility is an assignment to a different organization within the same commuting area.
- Geographic mobility is relocation outside the commuting area.

The Army imposes all three types of mobility as a condition for membership in the Acquisition Corps. Although involuntary mobility is its least preferred method for filling positions, it retains the

right to enforce it under two circumstances: to ensure that an employee receives field or headquarters experience, and to staff hard-to-fill positions with specialized skills in remote areas. The Navy requires no written mobility statement for Acquisition Corps membership. Although they feel certain types of employees, such as interns and senior managers, should probably be mobile, they believe it would be counterproductive and cost prohibitive to require all civilians to be geographically mobile. The Air Force does not specifically require a mobility agreement for Acquisition Corps membership, but different acquisition career fields (such as program management) require mobility agreements. Within their career fields, civilians indicate their geographic preferences. Defense agencies do not require geographic mobility. Personnel are only considered for employment in the geographic areas they choose.

In sum, DoD Components vary in their implementation of mobility requirements. The Army has chosen to institute the most comprehensive approach, to include mandatory geographic relocation; the Air Force leaves the matter up to each career field; and the Navy and DoD impose no mobility requirement.

Mobility agreements can be a double-edged sword. On one hand, they give Components maximum flexibility in assignment of personnel, facilitate broadening of work experience at different levels, and promote the ability of civilians to compete against their military counterparts. On the other hand, relocation costs are high, and the threat of involuntary relocation may discourage highly qualified candidates from joining the Acquisition Corps. In any case, it is debatable whether

parity between civilians and the military can ever be achieved without some normalization of mobility requirements.

CENTRAL REFERRAL SYSTEMS

DAWIA requires the use of centralized job referral systems.¹¹ The intent was to open positions to all Acquisition Corps members regardless of their current location. Again, Defense Components have taken different approaches. The Army's use of centralized job referral systems was not affected by DAWIA. The Army fills its critical acquisition positions via the Army Civilian Career Evaluation System (ACCES), a centralized referral system based on 10 independent career programs, which was in place before passage of DAWIA. Acquisition personnel must register in each ACCES career field for which they wish consideration. When vacancies arise, registrants are automatically considered for positions for which they are eligible. The Army also uses the Corps of Engineers referral system and Army-wide vacancy announcements to fill acquisition positions.

In addition, the Army is pursuing some ambitious new initiatives. Its goal is to have a centrally managed program, with clearly established career paths that will include rotational assignments across functions and organizations. It intends to

"The Army has chosen to institute the most comprehensive approach, to include mandatory geographic relocation; the Air Force leaves the matter up to each career field; and the Navy and DoD impose no mobility requirement."

assess the potential of acquisition workforce members in nine competencies (oral and written communications, problem solving, leadership, interpersonal skills, self-direction, flexibility, decisiveness, and technical competency) and groom them for advancement. On an annual basis, it will select the most promising GS-13s for a "competitive develop-

"In sum, the Components have imposed different criteria for Acquisition Corps membership, and in some cases they restrict membership to those who are currently in acquisition billets."

ment group" that will be centrally managed, placed in developmental assignments for a three-year period, and given priority placement for education and training before be-

ing accessed into the Acquisition Corps.

In the future, the Army is considering expanding its centralized program manager selection board process to other key leadership positions. In addition, a pilot program is now under way to centrally administer lateral assignments for Senior Service College graduates and others within the Program Executive Officer (PEO) structure.

The Navy implemented a centralized job referral system in 1993. It consists of a voice mail system listing all civilian critical acquisition positions being filled through merit promotion. Using a Defense Switch Network (DSN), commercial, or 1-800 number, individuals can receive specific information about each vacancy and can obtain a copy of the announcement via fax.

The Air Force has 21 career fields involved in the acquisition workforce. Like

the Army, it uses a system that was in place before passage of DAWIA. Acquisition Corps members register for career programs for which they are eligible, and they complete a "dream sheet" to indicate their interest in geographic areas. Vacancies for acquisition positions at levels GS-13 through GS-15 are sent to the civilian personnel center, which maintains the database for the central referral system. The system generates a list of the top 30 candidates: 15 available for promotion and 15 available for lateral assignment. The selecting official makes his or her selection from that list of candidates, conducting interviews if desired. Thus Air Force Acquisition Corps members are automatically considered for positions as they become available.

The Director for Acquisition Education, Training, and Career Development has established a centralized referral system (CRS) to cover critical acquisition positions in the Office of the Secretary of Defense, the Joint Staff, and defense agencies, field activities, support activities, and schools. It covers occupational series groups across a wide variety of areas shown in the adjacent box.

The CRS basically functions as an announcement distribution system. Civilian personnel offices send vacancy announcements for critical acquisition positions to a central distribution point. From there, copies of the announcements are automatically sent to the homes of CRS registrants. Registrants receive only announcements that match the grade levels, career fields, occupational series groups, and geographic preferences for which they have registered.

To sum up, the Army and the Air Force use established centralized referral sys-

**OCCUPATIONAL SERIES
IN THE CENTRALIZED
REFERRAL SYSTEM**

Social science and psychology
Personnel management
Physical sciences
Biological sciences
Accounting and budgeting
Medical
Veterinary
Engineering
Legal
Information
Business and contracting
Copyright and Patents
Quality assurance
Equipment and facilities
Mathematics
Library
Transportation
Education
Investigation
Administrative
Supply

tems that are administered by functional area and automatically generate lists of potential candidates. The Navy's system provides job announcements in response to requests from applicants. DoD's system notifies applicants when a position that matches their qualifications and preferences becomes available. We advocate a uniform system that automatically identifies qualified candidates in accordance with their preferences, since this maximizes the chances of finding the best possible person for the job.

PROGRAM MANAGER SELECTION

DAWIA specified minimum experience and training requirements for personnel in program manager, deputy program manager, and PEO positions.¹² The law is silent, however, on what means should be used to select individuals to fill these senior acquisition positions. Military departments all use some type of selection board to fill program manager positions, and they all consider both military and civilian candidates (except for positions designated as military), but they vary somewhat in their procedures.

In the Army, program managers for Acquisition Category (ACAT) I and II programs are selected by the Best Qualified Board. This board usually meets in January of each year to review military and civilian records to identify the best qualified applicant for each program manager position. In addition, a program manager selection board convenes in March or April each year to select individuals for ACAT III program manager positions that have been designated for civilians only. Applications are made to the board, not to the position. Preferences of the applicants for geographic or organizational placement are not taken into consideration. If an applicant is selected for a position and declines to accept it, he or she is no longer eligible to be considered for another program manager position.

Navy ACAT I and II program managers and their deputies are selected by a centralized Best Qualified panel. Both military and civilian positions must be advertised, and a panel is used to rate and rank the candidates. Candidate slates are then prepared, listing the civilian and military personnel who rank highest. Call letters go out to the systems commands each

November or December, requesting applications for specific ACAT I and II program manager positions that are projected to become vacant over the next 18 months. These are distributed to GS-15s, who apply only for those positions for which they wish to be considered.

The Air Force operates in much the same way as the Army. Its selecting body is called the Material Management Board. Like the other military departments, it considers all civilian and military candidates for these positions.

In sum: All Military Departments use a central selection board process to evaluate civilian and military candidates for

"In sum: All Military Departments use a central selection board process to evaluate civilian and military candidates for major program manager positions. Yet, they operate under different rules."

major program manager positions. Yet, they operate under different rules. The main difference tends to be the penalty associated with declining an offer. If selected by the board, Army civilians

must accept a program manager position or they become ineligible for future promotion in the Army Acquisition Corps. Air Force civilians are removed from the program manager referral process for a one-year period. Navy civilians are not even considered for a given program manager position unless they apply for it.

We hesitate to make any global assertions on the efficacy of the boards used by military departments to select program managers and deputy program managers. However, we find that current methods do not result in a uniform process nor in an

equitable distribution of civilians in major program manager positions, as we shall see in the next section.

COMPARISON OF CIVILIAN AND MILITARY OPPORTUNITIES

DAWIA mandates a number of specific actions relative to the civilian workforce.¹³ It expressly limits conditions for preferring military over civilian personnel, and it calls for "a substantial increase in the proportion of civilians (as compared to armed forces personnel) serving in critical acquisition positions in general, in program manager positions, and in division head positions over the proportion of civilians."¹⁴

One metric for DAWIA implementation is the relative increase in the number and the proportion of civilians serving in senior acquisition positions. Another benchmark is the education, training, and assignments offered to the civilian workforce compared with those available prior to DAWIA. The following demographic trend data (Table 1) suggest that civilian acquisition personnel have not achieved parity with their military counterparts.

CIVILIAN VERSUS MILITARY PROGRAM MANAGERS

As indicated in the previous section, the Army, Navy, and Air Force all use some type of central board to select individuals to be program managers of Major Systems (ACAT I and II programs), with civilian and military personnel competing head to head. The selection board reviews an individual applicant's file against a prede-

Position	Civilian	Military
Acquisition workforce (%)	85	15
Senior acquisition positions (%) ¹	67	33
PEOs	8	16
ACAT I and II program managers	16	124
ACAT I and II deputy program managers	91	25
Division heads	2184	1577

¹Senior acquisition positions are made up of ACAT I and II program managers, deputy program managers, PEOs, senior contracting officials and division heads.

Table 1.
Distribution of Senior Acquisition Positions, All Components, 1996

terminated set of criteria and recommends selection of the most qualified individual for the position.

Despite these apparently impartial procedures, DAWIA has not had a dramatic impact on the number of civilians serving in ACAT I or ACAT II program manager positions. There is a disproportionate allocation between military and civilian acquisition professionals in these jobs. Table 2 shows that in 1996, military personnel constituted 15 percent of the acquisition workforce, yet they held 89 percent (124 out of a total of 140) of the ACAT I and ACAT II program manager positions.¹⁵

On the other hand, deputy program manager positions are predominantly civilian. The same 85 percent of the acquisition workforce that held only 11 percent (16 out of 140) of the program manager jobs held a more representative, but still

under-represented, 78 percent (91 out of 116) of the deputy program manager positions. Some sources suggest that the resulting mix is the optimal blend of military leadership and civilian continuity. Nevertheless, the fact remains that the distribution of ACAT I and ACAT II program manager and deputy program manager positions is inconsistent with the demographics of the population.

Trends over the past few years are not encouraging. Table 2 shows that civilian representation is declining in both critical acquisition positions and senior acquisition positions.¹⁶

To summarize, DAWIA called for the gradual increase in the number of civilian program managers as their training and experience equipped them to effectively compete to be "best qualified." The progress to date has been disappointing.

	1994	1995	1996
Percent critical acquisition positions (civilian)	85	80	79
Percent senior acquisition positions (civilian)	71	71	67

Table 2. Civilian Acquisition Positions, All Components

CIVILIAN VERSUS MILITARY EDUCATION AND TRAINING

Civilian participation in Senior Service School provides another benchmark of DAWIA's impact. The pinnacle of Professional Military Education (PME) is Senior Service School. As the last formal educational opportunity for most senior level officers (and civilians), it is a qualifying credential on the path to senior assignments. Thus we should expect to see an increase in civilian attendance at Senior Service Schools and all levels of PME since DAWIA was passed in 1991. There are six Senior Service Schools (Table 3).

The population of civilian and military attendees at each of the Senior Service Schools from 1990 through 1996 (the DAWIA years) is described in Appendix A and portrayed in Figure 1.

As the data indicate, civilian enrollment in the Senior Service Schools remained fairly constant (ranging from 110 to 123) from 1991 through 1994. The years 1995 and 1996 saw civilian participation in the Senior Acquisition Course (SAC) raise the combined figures for all schools to 140 and 143, respectively. The Senior Acquisition Course traces its origin to DAWIA and Defense Acquisition University. It has

SCHOOL	SERVICE
Army War College	Army
Naval War College	Navy
Air War College	Air Force
Marine Corps War College	Marine Corps
National War College	Joint
Industrial College of the Armed Forces ¹	Joint

¹Includes the Senior Acquisition Course established under DAWIA.

Table 3. Senior Service Schools

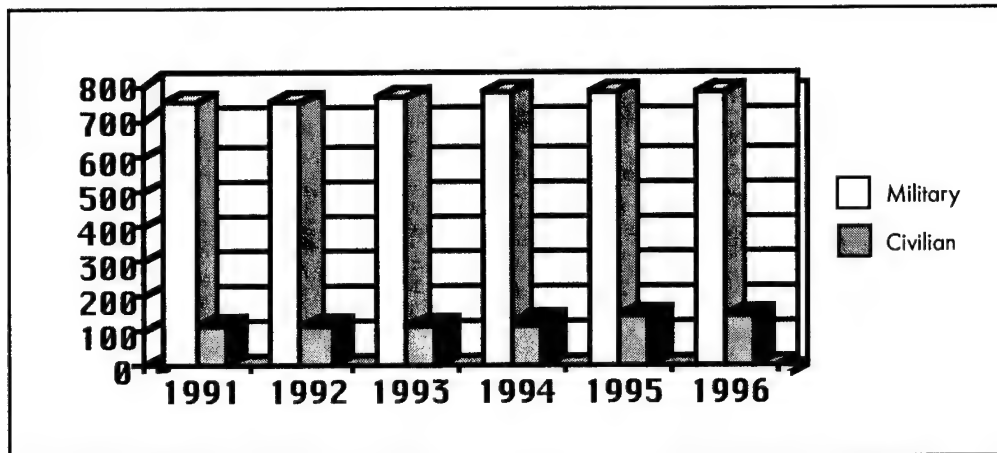


Figure 1. Military and Civilian Attendees in Senior Service School

helped, but not dramatically. A future study to evaluate the relative percentage of civilian and military Acquisition Corps members would be a useful undertaking.

The conclusion is that civilians continue to be under represented in certain categories of senior acquisition positions, such as ACAT I and II program managers. Further, they continue to be under represented across the board in all senior acquisition positions. Outside of the slight increases associated with the Senior Acquisition Course, DAWIA has had marginal effect on civilian participation in Senior Service Schools.

CONCLUSIONS

What has DAWIA accomplished? It has succeeded in prompting the DoD Components to take the steps necessary to professionalize the defense acquisition workforce. In response to DAWIA, the military departments have raised standards, increased training, and enhanced

development of their acquisition personnel. As a result, we believe, both military and civilian acquisition personnel have benefited over the past five years. DAWIA implementation has brought about many sorely needed changes and has allowed DoD Components to move forward to meet the daily acquisition challenges with a more highly trained and better equipped workforce.

However, change has been rather slow. DAWIA was enacted in 1991, yet the Components did not begin to accomplish many of its provisions until much later. Some attribute the delay to "service-unique culture," while others admit that implementation may not be as far along as they would like. In every case, however, those we interviewed felt that they are better off now than they were before DAWIA.

Each Component we interviewed was genuinely concerned about its acquisition workforce. They shared a strong commitment to furthering professional workforce development. We were especially im-

pressed by the Navy's commitment to a full-time SES-level DACM, the Air Force central referral system and staffing process, and the recent Army initiatives to enhance its civilian acquisition workforce.

No doubt DAWIA has made a difference. However, more remains to be done. Our analysis revealed at least two areas in need of improvement: There is a lack of uniformity across DoD Components; there are disparate professional development opportunities for civilian and military personnel. We will now consider the reasons for these conditions and discuss why they matter.

LACK OF UNIFORMITY

Even though there is one law, implementation throughout the DoD Components is uneven. There is general compliance with DAWIA and DoD regulations, and to some extent there is uniformity across the Components. However, there are many instances where the same statutory provision was carried out differently.

"Our analysis revealed at least two areas in need of improvement: There is a lack of uniformity across DoD Components; there are disparate professional development opportunities for civilian and military personnel."

Since responsibility for implementation was delegated to the various Components, they established different requirements for Acquisition Corps membership, imposed different mobility rules, and used

different mechanisms to fill acquisition positions.

It is not very clear why the Components diverged in their policies and practices.

Tradition, culture, and internal politics probably drove many decisions. Does it really matter whether the Components differ from one another? Despite their differences, they are functioning relatively well and making incremental progress. Yet the law requires uniformity to the maximum extent practicable. What's more, similar policies and practices make sense in today's environment, which increasingly stresses the importance of joint operations.

We believe that the Office of the Secretary of Defense and the Military Departments could do more to match the right person to the job if they used an integrated centralized referral system. The original intent of the framers of DAWIA was to promote centralized referral for civilians, not only within military departments but across them. Draft recommendations of the House Armed Services Committee's Subcommittee on Investigations, dated 8 March 1990, called for the Under Secretary of Defense for Acquisition to "evaluate the feasibility and desirability of establishing a DoD-wide referral system that would enhance the ability of civilian acquisition personnel to acquire 'joint experience' as do military personnel." While this provision never made it into the final version of bill, we think the idea has merit. This is particularly true in view of the current emphasis on "jointness" and the reduced opportunities for advancement associated with the drawdown in acquisition programs.

CIVILIAN AND MILITARY DISPARITY

Despite small gains in the number of civilians that hold senior acquisition positions, there is still a significant disparity. The distribution of the acquisition

workforce and the relative makeup of military and civilian positions suggest a systemic bias in the process, which serves to provide better access to program manager positions for military members than for civilians.

Why is it, after five years of DAWIA-sponsored training and education, that selecting officials (and these include civilians) find civilians best qualified to be deputies and their military counterparts best qualified to be program managers? Is it bias? Is it education? Is it training? Is it culture? Is it Office of Personnel Management (OPM) constraints?

We think, in some respects, all of these elements contribute. Some officials believe that, on the strength of their training, military members make better leaders. Some believe that operational experience is a vital element in the program manager's makeup. Some argue that because civilians lack mobility, civilian program managers would limit promotion opportunities for junior members by encumbering positions indefinitely (although this is prohibited by law). Others believe that the different personnel systems make military more attractive than civilian managers. (They are easier to hire and fire!)

While it may be true that all of these issues have some bearing on selection, we are firmly convinced that selection boards continue to pick military members over civilian members for the very simple reason that they are better qualified for what are essentially leadership positions. Why do selection boards find them more qualified? The answer lies in the nature and breadth of experience that typifies the military versus civilian career. The cultural realities of the services and the per-

sonnel systems they employ are fundamental to this reality.

The military career is predicated upon a mix of assignments, training, and education. This mix features mobility, progression, challenge and leadership development. At its very core, it is a competitive "up or out" system. The fundamental competencies are broad perspective and leadership. The military path to success follows a series of relocations to jobs of increasing difficulty, com-

"...we are firmly convinced that selection boards continue to pick military members over civilian members for the very simple reason that they are better qualified for what are essentially leadership positions."

plexity, and visibility. It requires extensive Professional Military Education (PME), operational experience, and advanced academic degrees—usually technical. The competitive nature of the promotion system serves to retain only the most promising members in an ever-shrinking advancement pool.

The traditional civilian career path has been functionally based. Unlike the military path, which traverses the mountain to gain the summit, the civilian path is more of a spiral staircase. It focuses on depth and expertise in narrowly defined functional stovepipes. Promotion comes within a functional world where ever-increasing technical excellence (in accordance with OPM standards) is the basis for advancement. Lateral mobility across career fields is difficult and costly. Geographic mobility, though encouraged, is not necessarily required. Advanced tech-

nical and management degrees are required. PME is not. The fundamental value is technical competence and stability. Mobility and leadership were not critical attributes of the career civilian. This reality is grounded in OPM requirements and public law.

Qualifying experience, in a given functional area, is probably the most limiting factor in civilian career development. While OPM restrictions arguably protect and promote the best qualified for a given position, job series requirements and qualification standards combine to effectively limit civilians to a single functional career path, often in a single location. Where the military system develops mobile generalist leaders, the civilian system develops stable functional experts.

Program management is all about leadership and broad perspective. In order to compete effectively for the top jobs, civilians need to have at least the same lev-

els of education, training, and experience as those against whom they must compete.

On the basis of our study, DAWIA has yet to effect the "substantial" civilian advancement it was intended to achieve. Inequities in education, training, and experience persist, but they can be overcome as long as managers and employees alike are willing to commit to a career development program that promotes leadership (PME), broad perspective (functional mobility), and diverse work experience (organizational mobility).

Why is this important? First of all, the law requires it. Second, good business practice mandates effective and efficient use of all our human resources, enabling the best and the brightest, whether civilian or military, to rise to the most senior acquisition positions. Finally, and perhaps most important, it is the right thing to do.

APPENDIX A

Senior Service School Attendance: 1991 Through 1996

ENDNOTES

1. Public Law 101-510, "National Defense Authorization Act for Fiscal Year 1991," Title XII, *Defense Acquisition Workforce Improvement Act*. November 5, 1990. (Sections 1701-1764 of Title 10, United States Code).
2. For purposes of this study, DoD Components are defined as the Military Departments (Army, Navy, Air Force) and Defense Agencies.
3. "Section 1701(b) UNIFORM IMPLEMENTATION.—The Secretary (of Defense) shall ensure that, to the *maximum extent practicable*, acquisition workforce policies and procedures established in accordance with this chapter are *uniform* in their implementation throughout the Department of Defense."
4. The Director for Acquisition Education, Training and Career Development was established within the Office of the Undersecretary of Defense for Acquisition and Technology to oversee DAWIA implementation and to manage the acquisition workforce within defense agencies. The Director for Acquisition Career Management was established within each Military Department under the respective Service Acquisition Executive to manage the acquisition workforce within each Military Department
5. For the sake of brevity, this is an oversimplification of the statutory requirements for all acquisition career fields
6. Public Law 101-510, Title 10, U.S.C., Section 1732.
7. "Section 1722(d) Best qualified.—The Secretary of Defense shall ensure that the policies established under this chapter are designed to provide for the selection of the *best qualified individual* for a position, consistent with other applicable law."
8. "Acquisition Professional Community" is the Navy term for Acquisition Corps. The Navy decided against the term "Acquisition Corps" to avoid confusion with its other "corps."
9. *Welcome to the Acquisition Workforce*, An Introductory Guide to the Department of the Navy Acquisition Workforce Program, p. 10.
10. "Section 1732(e) MOBILITY STATEMENTS.—(1) The Secretary of Defense is authorized to require civilians in an Acquisition Corps to sign mobility statements. (2) The Secretary of Defense shall identify which categories of civilians in an Acquisition Corps, as a condition of serving in the corps, shall be required to sign mobility statements."

11. "Section 1734 Part (f)—The Secretary of Defense shall prescribe regulations providing for the use of centralized lists to ensure that persons are selected for critical positions without regard to geographic location of applicants for such positions."
12. Public Law 101-510, Title 10, U.S.C., Section 1735(b) and (c).
13. "Section 1722(c) OPPORTUNITIES FOR CIVILIANS TO QUALITY. The Secretary of Defense shall ensure that civilian personnel are provided the opportunity to acquire the education, training and experience necessary to qualify for senior acquisition positions."
14. "Section 1722(e) MANAGEMENT OF WORKFORCE. The Secretary of Defense shall ensure that the acquisition workforce is managed such that...there is a substantial increase in the proportion of civilians (as compared to armed forces personnel) serving in critical acquisition positions in general, in program manager positions, and in division head positions over the proportion of civilians (as compared to armed forces personnel) in such positions on October 1, 1990."
15. Director, Acquisition Education, Training and Career Development memorandum, subject: Secretary of Defense's FY 1996 (1997) Annual Report to the Congress, 5 February 1997.
17. Ibid.
- "Section 1722(b). LIMITATION ON PREFERENCE FOR MILITARY PERSONNEL—(1) The Secretary of Defense shall ensure that no requirement or preference for a member of the armed forces is used in the consideration of persons for acquisition positions, except (when required by law, when essential for performance of the duties of the position, or for another compelling reason)."

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QUALITY FUNCTION DEPLOYMENT AS A TOOL FOR IMPLEMENTING COST AS AN INDEPENDENT VARIABLE

David R. Wollover

The essence of cost as an independent variable (CAIV) is using reliable tools to balance cost with mission needs for new program development. This article addresses concerns about implementing CAIV for Department of Defense (DoD) acquisition programs that vary by scope, budget, and dimension. Perhaps no single CAIV implementation tool is robust enough to apply to all cases. However, we are interested in tools to implement CAIV for a maximum number of programs to collect lessons learned and related beneficial aspects of the CAIV learning curve.

This article describes and illustrates Quality Function Deployment (QFD) as a tool with good potential to help implement CAIV for a variety of DoD acquisition programs. An example of a generic acquisition system (a weapon system in this writing) not attributed to any specific program is used. The example is actually elementary compared to some advanced QFD applications. However, it is still manifold enough to illustrate a fairly detailed QFD application. While this paper focuses on a weapon system, the same process may be applied to automated information system (AIS) programs, with appropriate modifications.

QFD consists of six general steps: (a) identifying and analyzing customer needs and requirements, (b) identifying technical performance measures (TPMs), (c) benchmarking TPMs, (d) assigning priority to customer requirements, (e) establishing TPMs to identify specific design characteristics, and (f) evolving technical performance measures into the follow-up design phase's requirements. This elementary example will illustrate QFD, providing a framework to transform vague customer requirement statements into TPMs that are deployed throughout system design and development.

DoD has adopted a strategy to use aggressive, realistic cost objectives to acquire systems, and managing risks to obtain objectives. These objectives

must balance mission needs with projected out-year resources, accounting for existing technology as well as high-confidence maturation of new technologies.

This concept is called cost as an independent variable (CAIV), meaning that once a system's performance and objective costs are decided on the basis of cost-performance tradeoffs, the acquisition process establishes cost as a constraint, rather than as a dependent variable, while still getting the needed military capability (ODUSD [AR]), 1996). Tradeoffs are made among cost, schedule, and performance based on CAIV analysis (Office of the Secretary of Defense, 1996).

In a Dec. 4, 1995, memorandum on life cycle cost reduction, Dr. Paul Kaminski requested: (a) cost performance trades; (b) aggressive program management, making cost a major independent driver, while preserving warfighter requirements; (c) expanding use of existing techniques to meet program goals; and (d) reducing unnecessary program and product complexity (Kaminski, 1995).

Guidance attached to Kaminski's memorandum calls for CAIV to include: (a) adopting aggressive realistic cost goals for operations and support, as well as production, with well-defined steps leading to objectives; (b) using existing practices proven to have managed meeting customer requirements; and (c) formalizing

the cost-performance tradeoff process through performance specifications used to state requirements in a manner that clearly directs the CAIV process to evaluate all pertinent design parameters that serve as key metrics and observables, while assuring preserving needed military capability (Longuemare, 1995).

CAIV METRIC AND OBSERVABLES

The CAIV Working Group Paper Summary, an attachment to Kaminski (1995), describes the instrumental role of key metrics and observables. This attachment describes the importance of setting early cost objectives. The ability to set cost objectives depends on results of early cost-performance tradeoff analyses. Metrics and observables are needed to assess CAIV implementation progress.

Metrics and observables identify observable steps for meeting aggressive production and operations and support cost objectives, and then managing for their achievement. Conrow (1995, p. 209) indicates that a significant influence on creating DoD program development cost, and technical and schedule risk is incorrectly

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specified technical possibilities. Both government and contractors "routinely underestimate the risk present in military programs." Risk reduction steps for technology development and application, manufacturing, and operations can be guided by unbiased metrics and observables tailored to specific programs.

SIGNIFICANCE OF TECHNICAL PERFORMANCE MEASURES

Examining the DoD description of "key metrics and observables" (Kaminski, 1995) reveals they are similar to what system engineers call technical performance measures (TPMs) (Verma, Chilakapati, & Blanchard, 1996, p. 39). Titles are less important than insights to correlations among key performance parameters (KPPs), critical technical parameters (CTPs), or other TPM candidates described in the literature, for example, by Higgins (1997, pp. 45-46) and Jones (1996, p. 151).

Risks to meeting performance requirements with aggressive cost goals must be managed through iterated cost, performance, and schedule tradeoffs, identifying performance, manufacturing, or operations uncertainties, and demonstrating solutions prior to final design. We seek to efficiently manage weapon system complexity, defined here as an evolving large number of interfaces, parts, and final testing requirements among maturing system configuration elements (Gindele, 1996, p. 66). In this context we seek proven means to systematically organize all independent variables and their interrelationships.

Commitments to technology, system configuration, performance, and life cycle

cost are strong even in early system design. Many system characteristics interact; consequences of these static and dynamic interactions are rarely well evaluated or understood. There are ample opportunities to reduce costs while life cycle decisions continue to be made. Progress may be created by techniques that enable earlier use of integrated design information (Fabrycky, 1994, pp. 134-136).

The best time to reduce life cycle costs is early in the acquisition process, when cost-performance tradeoff analyses are conducted to decide an acquisition approach. However, because factors both internal and external to the program change, tradeoffs must occur throughout the acquisition process, and key TPMs may also significantly change throughout program evolution.

Still, it is critical to CAIV that the process of setting TPMs reflecting cost and performance objectives begin as early as possible. The ability to achieve cost objectives greatly depends on early executed cost-performance tradeoffs, including using TPMs to measure and thus better manage risk mitigation. Specifically, for example, as in the case of the F-22 program, TPM changes may be observed in direct response to risk reduction efforts (Justice, 1996, p. 70).

Consequently, applying CAIV TPMs to DoD programs entails: (a) setting cost and performance objectives as early as possible; (b) quantifying these objectives as

"Titles are less important than insights to correlations among key performance parameters (KPPs), critical technical parameters (CTPs), or other TPM candidates described in the literature..."

TPM threshold values, tailored to specific assets and activities; (c) setting pathways supporting observable transitions between objective-oriented actions; (d) adhering to a cost-performance tradeoff process that has structured all relationships among TPMs; and (e) empowering program managers to flexibly respond to changes in the set(s) of TPMs and their values.

INTRODUCTION TO QUALITY FUNCTION DEPLOYMENT

Quality function deployment (QFD) is a well-established procedure that essentially uses a series of interdependent matrices. The matrices are used to organize and translate customer requirements, in an integrated fashion, to the successive steps that ultimately meet these requirements.

QFD has been used in a wide variety of

industries to use TPMs to translate and literally map customer needs into objective product outcomes. QFD is a historically proven means to guide process

"Quality function deployment (QFD) is a well-established procedure that essentially uses a series of interdependent matrices."

development using TPMs to systematically organize all independent variables (cost, etc.), and their interrelationships. QFD is cited as the most widespread implementation of total quality management (TQM) (Sage, 1992, p. 222), and as a key facilitating tool in concurrent engineering environments (Menon et al., 1994, p. 91).

QFD is a process tool that helps strengthen management of key elements of the system engineering process for DoD advanced technology development programs. QFD is structured to accommodate vaguely stated customer specifications, and through a series of interdependent matrices, allocate and map requirements into specific design strategies, development processes, product characteristics, and program operations controls. For each intended result of the design and production process, engineers identify TPMs, and then specify corresponding threshold values to be met in order to achieve the required features of the overall system. These assignments set the minimum levels of achievement required to satisfy customer requirements.

ORIGINS OF QUALITY FUNCTION DEPLOYMENT

QFD was developed in the late 1960s by Shigeru Mizano of the Tokyo Institute of Technology (Menon et al. 1994, p. 94). Mitsubishi Heavy Industries also began to use it then on supertanker projects at Kobe Shipyard. Mitsubishi tried to build 300-yard-long supertankers having sophisticated propulsion, maneuvering, and balance control, challenging design and manufacturing logistical requirements, and having essentially no production line (Guinta and Praizler, 1993, p. 1).

Toyota adopted the Kobe shipyard QFD methodology in the mid-1970s. Toyota set performance benchmarks combined with customer focus groups. They experienced 40 percent reductions in new model de-

velopment costs, and a 50 percent reduction in development time (Menon et al. 1994, p. 94; Prasad, 1996, p. 82). Panasonic Consumer Electronics pushed QFD to greater limits in the mid-1970s. They used it to predict what consumers would want in the future, ergo their slogan "Just slightly ahead of our time" (Guinta and Praizler, 1993, p. 4).

A 1986 survey of Japanese Union of Scientists and Engineers reported that 54% used QFD, most of them in high technology and transportation industries. The Japanese exploited QFD to structure production and supporting operations to become less sensitive to variations caused by operators, equipment, and materials (Guinta and Praizler, 1993, p. 7). A most interesting historical note is that QFD was applied principally in companies and products primary to Japan's export business, particularly to the United States (Sanchez et al., 1993, p. 239).

THE UNITED STATES EXPERIENCE WITH QFD

Ford Automotive applied QFD in the early 1980s, using it to reorganize sequential functions to concurrent interaction of design, engineering, and manufacturing. Ford used more than 50 applications of QFD to (a) establish quality goals; (b) identify customers and others affected; (c) discover customer needs, such as increased reliability; (d) develop longer maintenance-free operation; (e) clarify the impact of manufacturing process plans on design; and (f) establish process controls coordination among functions (Hauser and Clausing, 1988, p. 63).

Ernst and Young innovated QFD applied to the paper products industry during 1990, where they included importance weighting, measured correlation among customer requirements, and completed competitive evaluations (a.k.a. "benchmarking" (Juran and Gryna, 1993, p. 255).

Thiokol Strategic Operations used QFD specifically to better measure and certify its parts suppliers, and consequently reduce development time to build strategic and tactical weapon system solid rocket motors (Guinta and Praizler, 1993, p. 13).

"Other companies using QFD include Aerojet Ordnance, ITT, IBM, Digital Equipment, Texas Instruments, Chrysler, General Motors, Procter and Gamble, Deere & Company, Polaroid, Rockwell International, Hughes Aircraft, and Hewlett Packard."

Other companies using QFD include Aerojet Ordnance, ITT, IBM, Digital Equipment, Texas Instruments, Chrysler, General Motors, Procter and Gamble, Deere & Company, Polaroid, Rockwell International, Hughes Aircraft, and Hewlett Packard (Sanchez et al., 1993, p. 239). Research by Guinta and Praizler (1993, p. 8) revealed that various domestic service and manufacturing companies using QFD experienced 50 percent cost reductions, and 33 percent project time reductions.

The DoD Joint Strike Fighter Program (JSFP) has an activity referred to as the Strategy-to-Task Technology QFD II Analysis, which has been awarded the American Supplier Institute (ASI) "Best Application" Award, recognizing exem-

plary use of QFD. This award was granted at the 1995 ASI Product Development Symposium. ASI cited this QFD II analysis as "the most robust aggressive use of QFD to analyze weapon system requirements seen to date." The award was presented by Dr. Genichi Taguchi, a four-time Deming Prize winner (JSFP, 1996a).

QFD has been successfully used in a wide variety of industries: aircraft, aerospace, automobiles, computer software, construction equipment, copiers, consumer goods, electronics, paper products, shipbuilding, and textiles (Menon et al.,

"QFD has been successfully used in a wide variety of industries: aircraft, aerospace, automobiles, computer software, construction equipment, copiers, consumer goods, electronics, paper products, shipbuilding, and textiles."

1994). The literature review, taken together, reliably indicates that QFD is deeply integrated into our commercial industry culture.

United States military cost-constrained effectiveness is influenced by our quality of

organizing and deploying technology according to specific functions. Other nations that compete militarily with the United States are evidencing their understanding of this (Brauchli, 1997, p. A14; Chen, 1997, p. A15; Fisher, 1996, p. A18). The lessons learned from the competitive strategies practiced under Secretary of Defense Casper Weinberger during the Reagan administration are not lost in this era characterized by aggressive nations actively seeking technologies providing greater military leverage.

Research by Pisano and Wheelwright demonstrates that outstanding high-tech companies such as Intel and Hewlett-Packard have integrated their product development skills with new focus on process development, and built unique sustainable competitive positions without expending more resources (1995, p. 105). The type of plan chosen does make a difference!

HOW WELL-SUITED IS QUALITY FUNCTION DEPLOYMENT TO DoD CAIV?

The applicability of QFD to CAIV is enhanced through the instrumental role of integrated product and process development (IPPD). IPPD is a philosophy of integrating all acquisition activities throughout the program life cycle. Integrated product teams (IPTs) are at the core of IPPD; IPTs are most instrumental to CAIV development and implementation.

A standardized structure for cost IPT operations is desirable for common implementation of CAIV initiatives across all DoD programs. System-level cost objectives, in turn decomposed to the sub-system level, are key technical performance measures shared by the program manager and corresponding IPTs. Cost/Performance IPTs (CPIPTs) are empowered to recommend engineering and design changes to the program manager.

IPPD facilitates IPTs for synthesizing acquisition activities throughout the program life cycle. As such, IPTs offer DoD an unprecedented opportunity to implement QFD as an interfunctional planning and communications tool. This is especially true for currently planned advanced

military technology implementation programs that require demonstrating a clear path toward reducing costs as well as meeting operational requirements (Wollover and Koontz, 1996, pp. 1-7).

ILLUSTRATION OF APPLYING QFD: GENERIC WEAPON SYSTEM DESIGN

Now we'll illustrate the application of QFD to the process of developing a generic weapon system. A notional weapon system example was selected to provide adequate design complexity, to permit a fairly detailed QFD application example. This example system need not be platform-specific; it is most broadly considered deployable to strike any target (e.g., underwater, surface, or airborne) from any platform (e.g., human, vehicle, aircraft, ship, spacecraft).

The QFD process consists of the following steps: (a) identifying and analyzing customer needs and requirements, (b) identifying TPMs, (c) benchmarking TPMs, (d) assigning priority to customer requirements, (e) establishing TPMs to identify specific design characteristics, and (f) evolving TPMs into the follow-up design phase's requirements. Actual steps do vary in the literature (Guinta and Praizler, 1993; Sanchez et al., 1993; Menon et al., 1994; Verma et al., 1996). The above steps suit our example.

IDENTIFY AND ANALYZE CUSTOMER NEEDS AND REQUIREMENTS

Customer need is defined in the context of a single on-target engagement. Ini-

tially, customer language is qualitative and subjective, imparting vagueness and imprecision to the early weapon system design. For example, needs such as maximizing mission effectiveness, maximizing affordability, maximizing supportability, minimizing risk, and optimizing personnel use are all too general for design engineers to immediately respond to. Hence these fuzzy statements are analyzed and translated into more specific requirements to better understand and respond to the perceived deficiency.

The first two columns of Table 1 illustrate these translations. For example, "maximize mission effectiveness" is translated into more concrete goals, such as "locate, track, reach, and destroy target." Developing a common dictionary for the overall QFD model aids in understanding user requirements in light of later tradeoff decisions (Bregard and Chasteen, 1996, p. 172). Once identified, similar customer requirements are grouped with like functional items. Referring again to Table 1, note how the five general customer requirements are the basis of the grouping of subsequent more concrete requirement statements.

IDENTIFY TECHNICAL PERFORMANCE MEASURES

TPMs are the keys to estimating progress for the weapon system's design and development. As "design-dependent parameters," TPMs offer various functionalities. They provide visibility into the status of actual versus required system performance, define corresponding future design goals, provide guideposts to evaluating design concepts and configurations, provide early detection of perfor-

Table 1. Notional Generic Weapon System Objectives Table

CUSTOMER REQUIREMENTS ^a		TPM	QUANTITATIVE REQUIREMENT
Maximize mission effectiveness	Locate target	Motor burnout velocity	(km/sec)
	Track target	Range	(km)
	Reach target	Maneuverability	(G/ms)
	Destroy target	Data processing speed	Mhz
		Data reception speed	Kb/Sec
		Length * diameter	M ^ 2
		Mass	kg
		Sensor accuracy	S / N
Maximize affordability	Minimize R&D cost	R&D	Constant year \$M
	Minimize production cost	Production	Constant year \$M
	Minimize support cost	O&S	Constant year \$M
	Minimize operations cost		
Maximize supportability	Maximize reliability	MTBF	Months
		Failure rate	Failures / mission
			Engagement
		MTBM	Months
	Maximize maintainability	Mean prevent maint. time -BITE (MPMT-B)	Minutes
		Mean prevent maint. time -ExTE (MPMT-E)	Minutes
		Mean corr. maint. time (MCMT) - org. level	Minutes
Minimize risk	Maximize producibility	Amount of major modifications (Reintegrating subsystems)	Percent
		Amount of minor modifications (Repackaging subsystems)	Percent
	Minimize design complexity	Hardware complexity	No. of interfaces/No. subsystems
		Software complexity	No. of interfaces/No. subsystems
		Subsystems integration complexity	No. of interfaces/No. subsystems
Optimize personnel use	Maximize operator effectiveness	Operator response times	Seconds
		Errors per mission engagement	No. errors
	Minimize Support Errors	Errors per testing event series	No. errors
		Errors per maintenance action	No. errors
	Optimize anthropometric factors	Size of maintenance access panel areas	In. x in. x in.
		Time to open each maintenance access panel	Seconds
	Optimize sensory factors	Each maintenance access panel lighted	Lumens
		Color coded panels	Indicate tool needs

^a Ranking Order determined on basis of customer perceived relative degree of shortfall toward existing benchmark

^b Because Mission Engagements are not continuous, it is readily assumed that the relationship between Reliability and Operating Time / MTBF is not exponential. Hence MTBF and Failure Rate may be somewhat more independently specified as design goals.

Quality Function Deployment as a Tool for Implementing Cost as an Independent Variable

mance problems requiring management attention, assess technical impact of proposed changes, and contrast implications of design alternatives. Consequently,

TPMs are integral to the program's risk management.

At this early stage of design, TPMs are key parameters that are under the control

**Table 2. Notional Generic Weapon System Objectives Table
Benchmarking of Technical Performance Measures
Pre-Rank-Ordering**

Technical Performance Measure	Quantitative Requirement	Current Benchmark (Competing systems)	Relative Importance
Motor burnout velocity (km/sec)	2N	N	8
Range (km)	1.5N	N	6
Maneuverability (G/ms)	2N	N	8
Data processing speed	5N Mhz	N Mhz	3
Data reception speed	10N Kb/sec	N Kb/sec	3
Length * diameter	N Meter ^ 2	N Meter ^ 2	1
Mass	.8N Kg	N Kg	1
Sensor accuracy	2N:N Signal/noise	N:N Signal/noise	8
R&D (constant year \$M)	.9N Dollars	N Dollars	4
Production (constant year \$M)	.8N Dollars	N Dollars	6
O&S (constant year \$M)	.7N Dollars	N Dollars	7
MTBF	.5N Months	N Months	2
Failure (F) rate	.5N F / mission engagement	N F / Mission engagement	2
MTBM	.5N Months	N Months	1
Mean prevent. maint. time -BITE (MPMT-B)	.8N Minutes	N Minutes	1
Mean prevent. maint. time -ExTE (MPMT-E)	.8N Minutes	N Minutes	1
Mean corr. maint. time (MCMT) -Org Level	.8N Minutes	N Minutes	1
Amount of major modifications	.5N %	N %	7
Amount of minor modifications	.5N %	N %	3
Hardware complexity	Sustain	No. of Interfaces	4
Software complexity	Sustain	No. of Interfaces	4
Subsystems integration complexity	Sustain	No. of Interfaces	5
Operator response times	N Sec	N Sec	3
Errors per mission engagement	.5*(0.N) Errors	0.N Errors	5
Errors per testing event series	.5*(0.N) Errors	0.N Errors	1
Errors per maintenance action	.5*(0.N) Errors	0.N Errors	1
Size of maintenance access panel areas	Sustain	n in. x n in. x n in.	1
Time to open each maintenance panel	.8N Seconds	N Seconds	1
Each maintenance access panel lighted	1.5N Lumens	N Lumens	1
Color coded panels	Reflect tool needs	Using B&W symbols only	1

of the design team. They are manipulated either directly or indirectly to meet customer requirements. TPMs are tangible and describe any relevant system attribute in measurable terms.

TPM ratios may be used. An example is effectiveness-to-cost ratios, for which a very wide variety of options may be specified (Wollover, 1991, pp. 149–153). While discrete changes in design measures leading to distinct effectiveness changes may be discerned, effectiveness-to-cost ratios may be normalized so equivalent comparisons of TPMs may be made for purposes such as the six functions mentioned at the beginning of this section. Ratio examples are: system effectiveness to life cycle cost, or reliability to development cost. Ratios such as these may be specified in the form of $[gkD]$ customer benefit $-/[gkD]$ cost, to facilitate comparison of relative changes among alternative TPM values.

In Table 1, the TPMs in the third column evolve from the more concretely defined customer requirements shown in the second column. The fourth column displays specific quantitative requirements associated with each TPM.

BENCHMARK TECHNICAL PERFORMANCE MEASURES

Table 2 lists the TPMs and the quantitative requirement (the latter being the same measure found in the fourth column of Table 1). The third column in Table 2, "Current Benchmark," holds the corresponding quantified TPMs found either in the predecessor weapon system or in either domestic or foreign competing weapon systems. Consequently, the system developers would like to surpass these benchmarks.

PRIORITIZE CUSTOMER REQUIREMENTS

Various system requirements will likely conflict. For example, adding weapon speed and range conflicts with minimizing development and production costs. Consequently, assuming a limited budget, tradeoffs are inevitable. The issue here is on what basis should the various interdependent tradeoffs be made. To help resolve if not overcome these conflicts, the requirements are assigned relative weights that reflect the customer's priorities. For this step, there is little substitute for direct customer survey techniques (Salomone, 1995, p. 108), although appropriate weapon system operations simulations are invaluable for enhancing customer decision processes.

Here we have used an arbitrary and systematic process to assign relative weights, as follows. The last column of Table 2, "Relative Importance," is reserved for assigning customer weights to TPMs. The first pass through the entire TPM series assigned a weight, equal to one, to all TPMs. The second pass entailed assigning a relative weighting equal to two for more important TPMs. The third pass assigned weights of three to those progressively more important TPMs, and so on, until the sum of the relative importance measures equaled 100. Finally, this list of TPMs was sorted based on these relative importance measures; Table 3 lists these sorted TPMs.

The above ranking procedure is suitable for our illustration; more rigorous prioritizing procedures are available. For example, variations of the commonly referenced analytical hierarchy process (AHP) are cited in the literature (Armstrong et al. 1994, p. 72; Wasserman, 1993, p. 59; Lyman, 1990, p. 307). These proce-

**Table 3. Notional Generic Weapon System Objectives Table
Prioritization of Technical Performance Measures
Rank-Ordered According to Priority**

Technical Performance Measure	Quantitative Requirement	Current Benchmark (Competing Systems)	Relative Importance
Motor burnout velocity (km/sec)	2N	N	8
Maneuverability (G/ms)	2N	N	8
Sensor accuracy	2N:N Signal/noise	N:N Signal/noise	8
O&S (constant year \$M)	.7N Dollars	N Dollars	7
Amount of major modifications	.5N %	N %	7
Range (km)	1.5N	N	6
Production (constant year \$M)	.8N Dollars	N Dollars	6
Subsystems integration complexity	Sustain	No. of Interfaces	5
Errors per mission engagement	.5*(0.N) Errors	0.N Errors	5
R&D (constant year \$M)	.9N Dollars	N Dollars	4
Hardware complexity	Sustain	No. of Interfaces	4
Software complexity	Sustain	No. of Interfaces	4
Data processing speed	5N Mhz	N Mhz	3
Data reception speed	10N Kb/Sec	N Kb/Sec	3
Amount of minor modifications	.5N %	N %	3
Operator response times	N Sec.	N Sec	3
MTBF	.5N Months	N Months	2
Failure (F) rate	.5N F / Mission engagement	N F / Mission engagement	2
Length * diameter	N Meter ^ 2	N Meter ^ 2	1
Mass	.8N Kg	N Kg	1
MTBM	.5N Months	N Months	1
Mean prevent. maint. time -BITE (MPMT-B)	.8N Minutes	N Minutes	1
Mean prevent. maint. time -EXTE (MPMT-E)	.8N Minutes	N Minutes	1
Mean corr. maint. time (MCMT) -org. level	.8N Minutes	N Minutes	1
Errors per testing event series	.5*(0.N) Errors	0.N Errors	1
Errors per maintenance action	.5*(0.N) Errors	0.N Errors	1
Size of maintenance access panel areas	Sustain	N in. x N in. x N in.	1
Time to open each maintenance access panel	.8N Seconds	N Seconds	1
Each maintenance access panel lighted	1.5N Lumens	N Lumens	1
Color coded panels	Reflect tool needs	Using B&W symbols only	1

dures essentially are driven by using sophisticated customer query techniques to develop and assign explicit weighting variables that represent customer priorities. These techniques, while "method-

ologically intense," should result in fairly unambiguous communication of which customer inputs most greatly influence QFD.

Table 4. First-Order Quality Function Deployment Correlation Matrix

[illegible]

ESTABLISHING TPMs TO IDENTIFY SPECIFIC DESIGN CHARACTERISTICS

All TPMs are considered on an integrated basis using the QFD correlation matrices. This is the first opportunity to integrate all requirements, including effectiveness, cost, operations, and logistics support into the mainstream design and development process.

Configure the QFD matrix. Customer requirements from the first two columns of Table 1 are set as the "customer desired attributes" (Table 4, the first-order QFD matrix, left-hand section). These are the "whats" to be satisfied. In response to these requirements, TPMs from Tables 1 through 3 are positioned along the top of the matrix. These TPMs are the "hows," to the extent that they support customer requirements.

Correlate customer requirements With TPMs. This is the key step of the QFD process. It involves populating the correlation matrix to reflect program-directed or otherwise inherent cause and effect relationships. Each TPM is analyzed in terms of the extent of its influence on customer requirements.

Varying relative levels of this correlation are notionally depicted in the example correlation matrix (Table 4), ranging from a value of +3, the maximum positive correlation, depicted in the matrix as 3, to -3, the maximum negative correlation, depicted in the matrix as (3). We especially note that these values do not simply correlate, but rather indicate the degree to which the TPMs support the customer requirements. Three examples follow; their occurrences in the first-order QFD matrix shown in Table 4 are highlighted using

bold borders surrounding the relevant correlation cells.

Example 1: Note the negative correlations between the TPM mass and the customer requirements for minimizing R&D and production cost. Here, the matrix is not negatively correlating mass with cost, but with the customer requirement of minimizing cost.

Example 2: An interesting example occurs where all six Supportability TPMs are negatively correlated with R&D and production costs, but are more positively correlated with operations and support costs. This reflects the normative view purported by CAIV proponents that greater up-front investment in supportability is warranted for ultimately reducing overall life cycle costs through disproportionately greater savings in the operations and support phase of the program. This example particularly helps to emphasize QFD's utility in identifying clusters of interaction elements.

Example 3: The last example occurs to illustrate the relatively minor yet real contribution that increasing personnel performance (e.g., greater human response time, fewer errors, reduced maintenance durations) contributes to overall system performance reliability. This example is intended to call attention to the high value-added human machine interface (HMI) avenues to cost reduction such as anthropometric factors, as described generally by Blanchard and Fabrycky (1990, pp. 436-440), and as directly applied to advanced aerospace design as described by Reed (1994, pp. 54-59).

General evaluation of the correlation matrix. Empty matrix rows represent unaddressed customer requirements. Where this is so, the set of TPMs is reevaluated,

and additional TPMs are specified where needed. By contrast, empty columns in the matrix indicate design or other development actions that are not traced to any customer requirement; they may indicate either under-leveraged, redundant, or unnecessary system-level design requirements (Verma et al., 1995, pp. 38). Other matrix evaluation strategies not covered by the above example could involve the following five avenues:

- Contrast complimentary technical solutions versus each other, to assess the degree they conflict (Hartzell and Schmitz, 1996, p. 36). Correlations among design inputs may be shown using a triangular table at the top of the matrix. However, care is needed to validate the true interactions between design inputs, as many of these interactions may strengthen or weaken as the design evolves (Maisel, 1996, p. 16).
- Evaluate the functional (cause-effect) relationships among concurrent activities to determine not only how flexible the overall development process is, but where additional flexibility is most needed to maintain process responsiveness to customer requirements volatility (Jordan and Graves, 1995, pp. 577–583).
- Cooper and Chew argue that it is insufficient to focus on customers; competitors are a parallel concern (1996, p. 95). Expand the matrix to focus on competitors as well as customers, using key mission or other customer satisfaction TPMs. Use existing competitor TPMs in a bench-marking fashion, as illustrated earlier.
- Thurston and Locascio (1993, p. 208–213) use multiattribute utility theory to interpret QFD matrices as a general formulation of a design optimization problem. Customer requirements are expressed as constraint functions, and tradeoffs among design attributes are formally specified as sets of variables whose optimal values are solved using selected mathematical optimization models (p. 211).
- Sanchez et al. (1993, pp. 244–249) display perhaps the most creative and productive QFD application. They show matrix appendages containing trend line analyses of data populating the matrix, and separately illustrate iterating successive matrices to the extent of serving inputs to statistical process control. Both of these enhancements help take QFD beyond the realm of a cognitive tool to that of hard empirical data generator.

Other value-added assessments from checking the correlation matrix are likely. Well-populated QFD matrices permit synergistic insights particular to a program's chief concerns.

EVOLVE TPMs INTO THE NEXT DESIGN PHASE'S REQUIREMENTS

Table 5 illustrates the transition of the "hows" in the first-order matrix to the "whats" in the second-order matrix. This series of steps, where the TPM outputs of a n th-ordered matrix become input to the successive n th +1-ordered matrix, as the design resolution is enhanced, until system design detail has ideally progressed to the point where: (a) all significant design tradeoffs are defined and resolved,

Table 5. Second-Order Quality Function Deployment Correlation Matrix

TECHNICAL ENGINEERING CHARACTERISTICS		Motor thrust (Newtons)	Total missile Available fuel mass (kg)	Missile divert thruster thrust acceleration (m/s ²)	COTS processor generation upgrad (200 Mhz)	Missile uplink-receive antenna gain (watts)	Miniaturization techniques	Selection of lighter materials	Peak transmitted power (watts)	RELATIVE IMPORTANCE
MAXIMIZE MISSION EFFECTIVENESS	Motor burnout velocity (km/sec)	3	2				2	2		8
	Range (km)	3	3			1	2	2		6
	Maneuverability (G/ms)	1	2	3	2	1	1	1	1	8
	Data processing speed (MHz)				3		1			3
	Data reception speed (Kb/sec)				2	3	1		2	3
	Length * diameter (m * m)	1	2				3	2		1
	Mass (kg)	1	3				2	3		1
	Sensor accuracy (S/N)					1	1	1	3	8
TECHNICAL DIFFICULTY (10 = Most Difficult)		8	8	8	7	7	5	5	7	
IMPUTED IMPORTANCE (10 = Most Important)		8	6	8	3	3	1	1	8	

(b) specific subsystem or component packaging is determined and tested, so that (c) overall program risk is reduced to acceptable levels.

Third-, fourth-, fifth-, etc.-order QFD matrices are preferred for translating customer requirements into highly detailed subsystem attributes, or even detailed control of operations (Menon et al. 1994, p. 94). For diverse examples of progressive QFD translation matrix series used to translate the "voice of the customer" into the more evolved "voice of the engineer," see Guinta and Praizler (1993), Hauser and Clausing (1988), Sanchez et al. (1993), and Sage (1992). The number of translation matrices is influenced by the com-

plexity and diversity of the program, in combination with the degree of required design detail. While translation matrices content may vary widely, they all do have a similar structure.

USING QFD TO BENEFIT IMPLEMENTING CAIV

QFD's multi-attribute structure can systematically capture data and interrelate it in a variety of tailored arrangements. This enables higher quality integrated program analysis and evaluation (including cost and effectiveness analysis) earlier in the weapon system life cycle. With QFD's col-

lective knowledge, program managers can less ambiguously evaluate what technologies or other initiatives will fit in and advance the program.

QFD facilitates comprehensively displaying relationship nodes among cost and noncost variables. This encourages structured analyses to yield improved rank

"QFD is a procedure-oriented yet nonmechanistic enabling technology for new program development."

orderings into which cost reduction opportunities due to earlier discovery and resolution of conflicts are most significant, before large shares of system life cycle cost become locked in during the earliest program phases.

Also, there is perhaps no better tool to ascertain whether the degree of system definition and development is commensurate with requirements determination, or alternatively, whether requirements determination is lagging behind system specification and development.

The traditional system engineering process provides a standardized "top-down" context comprehensively to apply QFD to program management, as described, for example, by Blanchard and Fabrycky (1990, p. 22, 50). It consists of: conceptual design and advanced planning, preliminary systems design and advanced development, and detail system design and development.

Applying QFD through sound system engineering principles will allow greater exploitation of modern manufacturing processes and controls. Marshall and Vander Ha (1996, pp. 218–226) provide a per-

tinent beneficial example of the system engineering approach applied to designing space system ground segments to reduce operations costs.

QFD provides a consistent robust structure to arrange interactions among cross-functional team members. As organizations gain experience with QFD, the model becomes a source of historical information and "hard-wired" corporate memory. This promotes growing an integrated product team-facilitating learning curve. Thus, an expected output of implementing QFD is to advance the efficiency of the organization, especially for better controlling the flow of IPT interactions, while safeguarding against organizational de-evolution due to loss of corporate memory.

SUMMARY

QFD is a procedure-oriented yet nonmechanistic enabling technology for new program development. It provides a structured framework that uses TPMs to ensure that customer needs are deployed into all phases of design, development, production, and operations. This framework drives the process of developing a road map showing how key steps from design to manufacturing, operations, and support interact at various levels to fulfill customer requirements. This road map promotes documenting overall system logic, reflected by a series of interrelated matrices that translate customer needs into process and product characteristics. Well-documented QFD matrices provide a flexible dynamic communication vehicle of prior, present, and future actions. Thus, QFD provides a communications tool to

accelerate building better relationships and promote trust among cross-functional team members earlier in the system life cycle.

QFD is a team-building, consensus-oriented, flexibly disciplined approach that structures synthesizing new ideas. It works as a cognitive map to ease communication of evolving knowledge across cost performance integrated product team elements—enhancing their work in an integrated fashion to give customers what they are asking for. QFD can apply throughout steps ranging from requirements determination through design through delivery through operations and support.

Incorporating QFD in the design helps to identify critical driving design attributes that should be addressed up front, where they most greatly benefit design evolution.

QFD models integrate data from many areas: customer requirements, strategic plans, engineering expertise, cost, mission effectiveness, production capability, logistic support, hardware and software reliability, and operations and maintenance. The QFD model presents these data in a side-by-side format showing relationships, correlations, and conflicts. It can show, where needed, tradeoffs among requirements, resources, and organizations. A single-page QFD matrix can easily communicate what would require a large number of text pages.

By better connecting developer, user, and supporter, QFD facilitates making CAIV tradeoffs among performance, schedule, and cost. QFD's iterative nature of using progressively refined TPMs clarifies system design detail to where signifi-

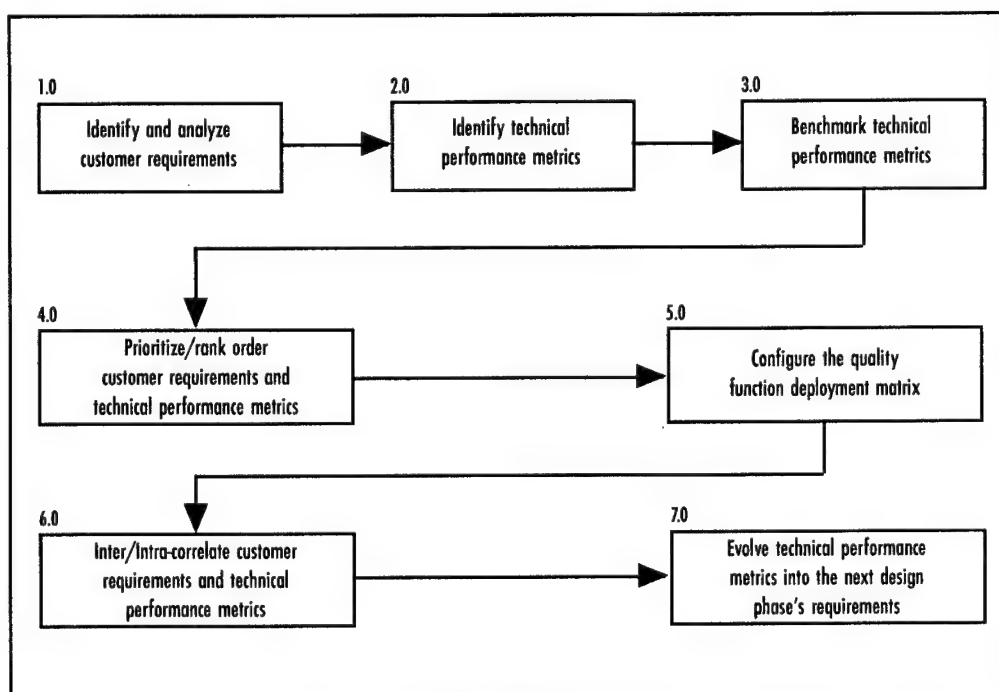


Figure 1. An Iteration of the Quality Function Deployment Process

cant design tradeoffs are defined and resolved, and subsystem function and packaging are determined and tested. This reduces program risk. Consequently, through exploiting detailed coordinated TPMs, QFD functions as a key part of program risk management. Figure 1 generalizes a single iteration of the overall QFD sequence.

One of the most challenging system development steps is sustaining the translation of subjective evolutionary customer requirement statements into objective engineering performance measures. Hartzell and Schmitz (1996, p. 36) point out that volatile customer requirements are a significant developmental program risk driver. Here, QFD may be used to relate different aspects of design, test, manufacturing, cost, reliability, and technology while both maintaining and archiving the changing customer's voice as the product development driving force. In this sense, QFD is usable as a DoD-equivalent of sound commercial business practices that do not lose sight of the fact that the developing voice of the customer is critical to successful implementation.

DoD has recognized QFD as a viable option in complex analyses involving integrated product teams. QFD has been acknowledged as a process enabling true understanding of user requirements and expectations, and documenting the best approach to satisfy requirements. DoD has cited QFD as a way to track the expected tradeoffs through determining require-

ments, (design decisions, production, and support (OUSD[A&T], 1996, pp. 2-5, 6).

No single management tool is a panacea. DoD acquisitions heavily dependent on integrated product teams will benefit from QFD. It is a strong tool for structuring IPT processes to comprehensively identify what to do, coordinate actions and their interfaces, monitor all tradeoffs among activities, and understand evolutions of program features and interrelationships. QFD imposes a self-revealing logic and structure to program development.

Implementing QFD emphasizes the requirement that IPT members take time to learn other functional areas' terminology and develop a common definition of terms, to build renaissance multidisciplinary teams. It is best to set QFD use objectives that stretch organizations, not break them.

Upper-level management may benefit from becoming familiar with QFD. This familiarity can furnish the benefit of understanding what questions to ask to evoke useful information from the QFD framework. A chief example of this is the QFD matrix revealing new relationships among cost and performance variables that indicate emerging cost reduction responsibilities associated with implementing new weapon system technologies. This information, revealed by QFD, may be then used to evolve management strategies that support organization efforts in a manner that guide development toward optimizing system cost-effectiveness.

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COST ESTIMATING RISK AND COST ESTIMATING UNCERTAINTY GUIDELINES

Timothy P. Anderson and Jeffrey S. Cherwonik

The Memorandum of Agreement signed by the Assistant Secretaries of the Navy for Research, Development, and Acquisition (ASN[RD&A]) and for Financial Management and Comptroller (FM&C) in June 1996 committed the Naval Center for Cost Analysis (NCCA) to improve cost analyses by helping program managers prepare better cost estimates. Recent computing advances make development of meaningful risk and uncertainty analyses easier, and these analyses can help managers do their job better.

The Memorandum of Agreement signed by the Assistant Secretaries of the Navy for Research, Development, and Acquisition (ASN[RD&A]) and for Financial Management and Comptroller (FM&C) on June 14, 1996, committed the Naval Center for Cost Analysis (NCCA) to "contribute to a more efficient Department of the Navy (DON) cost analysis process by assisting program managers prepare high-quality cost estimates for the acquisition chain of command...." One very important cost analysis issue that has received limited attention in the past by both NCCA and the program managers is "cost estimating risk and uncertainty."

Historically, program office estimates (POEs) as well as independent cost estimates (ICEs) have emphasized point rather than range estimates. With recent

advances in computing capability, it has become quite easy to develop meaningful risk and uncertainty analyses that can provide significant insight to program managers and milestone decision authorities (MDAs).

This article will explain why we should analyze cost estimating risk and uncertainty, delineate responsibilities, describe the procedures required, and help clarify the process using a sample problem.

BACKGROUND

WHY ANALYZE COST ESTIMATING RISK AND UNCERTAINTY?

The typical DoD life cycle cost estimate (LCCE) is developed by calculating the estimated cost of each of several work

breakdown structure elements and then adding them to derive a total LCCE. If the cost estimate for each work breakdown structure element represents the "best guess" of the cost for that particular element, then the sum of the cost estimates for each element represents, approximately, the "best guess" of the cost estimate for the whole system. Right? Wrong!

The above procedure has been in use for years. But the LCCE that results from this procedure is virtually guaranteed to be wrong! Assuming the estimate for each work breakdown structure element represents the mean or average cost for that element, then the only thing one can positively say about the resulting total cost point estimate is that it is the most likely cost out of a practically infinite number of possible costs.

Moreover, if all cost data come from a symmetric population (which they rarely do), then one can say that the total cost point estimate represents the 50th percentile cost. The interpretation of this is that the LCCE actually says "there is a 50 percent chance that the life cycle cost will be less than the point estimate; likewise, there is a corresponding 50 percent chance that

the life cycle cost will be greater than the point estimate." Yet, unfortunately, this estimate says nothing about the range of possible costs. Is the estimate, say, \$500 million plus or minus \$10 million? Or is the estimate \$500 million plus or minus \$400 million? Obviously, this information could be of vital interest to a program manager or a milestone decision authority.

HERE'S WHAT THE CAIG HAS TO SAY ABOUT IT

The Cost Analysis Improvement Group (CAIG) has delineated its own ideas concerning cost estimating uncertainty in DoD 5000.4-M, "Cost Analysis Guidance and Procedures." In this document the CAIG says:

Areas of cost estimating uncertainty will be identified and quantified. Uncertainty will be quantified by the use of probability distributions or ranges of cost. The presentation of this analysis should address cost uncertainty attributable to estimating errors; e.g., uncertainty inherent with estimating costs based on as-

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sumed values of independent variables outside data base ranges, and uncertainty attributed to other factors, such as performance and weight characteristics, new technology, manufacturing initiatives, inventory objectives, schedules, and financial condition of the contractor. The probability distributions, and assumptions used in preparing all range estimates, shall be documented...

Clearly then, there is well-documented interest in cost estimating uncertainty and risk at the highest levels of DoD.

WHAT IS THE DIFFERENCE BETWEEN RISK AND UNCERTAINTY?

Ask any two people for the definitions of risk and uncertainty and you will likely get two different answers. In addition, definitions vary among organizations. However, in the context of cost estimation, it is very important to have a precise definition of these two terms. NCCA has defined the two terms in the following way.

Cost estimating uncertainty. Uncertainty reflects one's confidence in the point estimate. Cost estimating uncertainty arises from the inaccuracies inherent in the cost estimating methodologies. For example, one might estimate a work break-

down structure element using a cost estimating relationship (CER) that, based on its underlying data, is accurate to within plus or minus some percentage. Consider the following CER.

$$\text{Cost (FY96\$K)} = 3.06 \times (\text{Weight in lbs})^{0.551}$$

Standard Error - 0.20 (+22.1%, -18.1%)

In this example, if the weight of the object being estimated is 100 pounds, then the estimated cost would range from \$31.7K to \$47.3K. The uncertainty in the estimate is captured by specifying the range (in this case \$31.7K to \$47.3K) in which the true cost of the object is likely to occur based on inaccuracies in the cost estimating methodology.

Cost estimating risk. Risk reflects one's confidence in the input parameters used to develop a cost estimate. Cost estimating risk arises from the inaccuracies inherent in the programmatic assumptions or technical data used as inputs to CERs. Consider the CER shown previously.

$$\text{Cost (FY96\$K)} = 3.06 \times (\text{Weight in lbs})^{0.551}$$

Standard Error - 0.20 (+22.1%, -18.1%)

If the weight of the object being estimated is 100 pounds plus or minus 5 pounds, then there exists another source of cost estimating error. First, the analyst has to account for the risk associated with

Table 1. Estimate Containing Elements of Risk and Uncertainty

	CER - 18.1%	BASELINE CER	CER + 22.1%
95 lbs	\$30.8K	\$37.6K	\$45.9K
100 lbs	\$31.7K	\$38.7K	\$47.3K
105 lbs	\$32.6K	\$39.8K	\$48.6K

the variance in the input parameter (5 pounds); then the analyst must deal with the uncertainty in the CER (+22.1%, -18.1%). Table 1 shows the steps needed to get at the final answer.

In this example, the estimated cost would range from \$30.8K to \$48.6K after considering both uncertainty and risk. Notice the wider range associated with both uncertainty and risk compared to the range associated with uncertainty alone.

RESPONSIBILITIES

Since cost estimates are now typically done by integrated product teams (IPTs), the responsibility for gathering data and documenting areas of risk and uncertainty will in most cases rest with the Cost IPT (CIPT). Exactly which analyst performs which function will be decided within each CIPT.

Ordinarily, the cost analyst will be responsible for selecting the methodology for estimating the cost of each work breakdown structure element. An important part of this responsibility is to ensure the statistics (uncertainty) associated with the cost estimating methodologies are known or are quantifiable. Often, the cost analyst will estimate cost with a single point analogy or an engineering buildup for which no apparent statistics exist. In these cases, the analyst should make every effort to go back to the source of the estimate and obtain a subjective probability or range assessment for these costs. As a minimum, the analyst should consider the variability reflected in previous cost estimates of analogous systems. In addition, although any CIPT analyst could perform

the task, the NCCA analyst should be responsible for developing the risk and uncertainty analysis since NCCA analysts are generally more experienced in such analyses. However, if the program manager's analyst performs the analysis, the NCCA analyst will be responsible for technical guidance and assistance.

In most cases, the program manager's analyst will be responsible for collecting the programmatic and technical data required as input values to the various cost estimating methodologies. This data, and particularly the associated risk data defined above, must be collected at the most appropriate level, depending on the analysis being done, prior to developing a cost estimate.

Historically, technical and programmatic data have been largely treated as constants. For example, an aircraft may be specified to weigh 22,000 pounds empty and to carry exactly 5000 rounds of ammunition. These numbers seldom come out exactly as specified. The responsibility of the program manager's analyst is to obtain reasonable bounds for these values, which may be used for risk analysis at a later time.

Therefore, whenever a value (e.g., quantity, weight, length) is obtained for future use in a cost estimate, it must be accompanied with a reasonable range based on consultation with knowledgeable individuals. Examples include "the aircraft's empty weight will most likely come in at 22,000 pounds, but may be as low as 21,000 pounds or as high as 25,500 pounds;" or "the gun's magazine is expected to carry between 4800 and 5200 rounds of ammunition when fully loaded."

Of course, there will be some values that contain no variability. These should

be indicated also. An example might be "the torpedo must be exactly 24 inches in diameter since it has to fit into an existing unmodified launcher."

Finally, in order to do a meaningful risk and uncertainty analysis, all cost estimates that are derived from lower level data must be documented. For example, if the program office estimates a cost based on empty weight and magazine capacity, the risk and uncertainty analyst must have visibility into the values (and their associated ranges) that were used to develop the estimate. In addition, the cost analyst must document all CERs and cost factors to include statistical information such as variance, standard deviation, and coefficients of variation.

PROCEDURES

The basic process required to perform a cost risk and uncertainty analysis is first to quantify each element of the cost esti-

mate in terms of its statistical properties such as mean or average, standard deviation, range, most likely cost, lowest possible cost, or highest possible cost. Second is to perform a Monte Carlo simulation. With this technique one takes a random sample from the probability distribution of each cost element. The sum of all randomly sampled cost elements is then taken to be one random sample of the total cost. This procedure is repeated many times. The result of this process is a probability distribution about the cost estimate. Figure 1 displays a representative risk and uncertainty analysis of average unit production phase costs from a precision-guided munition program. This analysis is the result of 10,000 iterations using a commercial Monte Carlo simulation model. The mean cost is estimated at \$33.1K, the standard deviation is \$5.7K, and the range of nearly all possible outcomes is from \$15K to \$50K.

The mean, plus or minus one standard deviation, may be interpreted as the range in which one can be 68 percent sure the

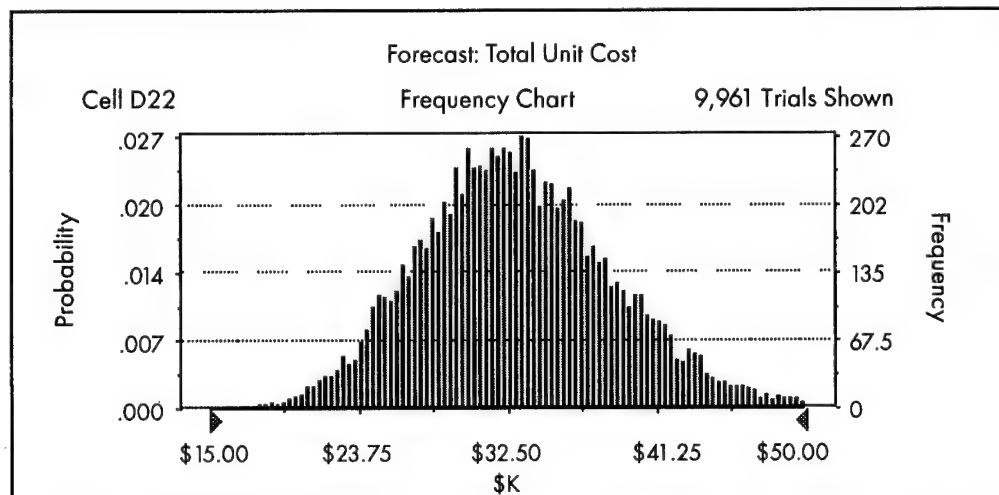


Figure 1. Example of a Risk and Uncertainty Analysis

true cost of the program will occur. Thus, in this example, the program manager can be 68 percent confident that the true average unit production phase cost for the baseline program will fall between \$27.4K and \$38.8K. Consequently, there is a 16 percent chance that the true cost will be below \$27.4K and a corresponding 16 percent chance that the true cost will be higher than \$38.8K. This information is much more useful to the program manager than the simple statement "the average unit production phase cost is estimated at \$33.1K."

AN EXAMPLE RISK AND UNCERTAINTY ANALYSIS

The following example of a risk and uncertainty analysis is intended to solidify the concepts discussed previously. In this example, a risk and uncertainty analysis will be performed on each individual work breakdown structure element using a Monte Carlo simulation. Additionally, an overall risk and uncertainty analysis will be conducted on the rolled up estimate using the same methodology.

Suppose you are asked to perform a risk and uncertainty analysis on a missile guidance and control (G&C) unit cost estimate (for expediency, learning curve phenomena will be temporarily ignored). The work breakdown structure for the G&C consists of a seeker and a processor.

SEEKER RISK AND UNCERTAINTY ANALYSIS

The program manager's cost analyst discussed the properties of the seeker with the engineer responsible for its design. The cost analyst has found a CER to estimate the unit cost of the seeker, which has operating frequency as its input variable. The CER is shown below.

$$\begin{aligned}\text{Seeker cost (FY 96 \$K)} &= 0.41 \times (\text{Freq. in khz})^{0.78} \\ \text{Standard error} &= 0.17 (+18.5\%, -15.6\%)\end{aligned}$$

According to the engineer, there is an 80 percent chance that the seeker will operate at 120 khz, but, due to design constraints, there is a corresponding 20 percent chance that it will operate at 80 khz. The risk associated with the seeker cost is a function of the choice of operating frequency (120 khz or 80 khz). The uncertainty is tied to the CER (+18.5%, -15.6%). This situation can be modeled as seen in Figure 2, where risk is modeled using a discrete probability distribution and uncertainty is modeled using a log normal probability distribution.

Based on a Monte Carlo simulation with 10,000 iterations, the mean unit cost estimate is \$16.27K with a standard deviation of \$3.37K.¹ Therefore, we see a 68 percent chance that the true cost of the seeker will fall within the mean plus or minus one standard deviation (\$12.90K to \$19.64K) while the range of nearly all possible costs varies from approximately \$7.50K to \$27.50K.

¹ The mean and standard deviation reported here are actually the sample mean and sample standard deviation of the 10,000 data points resulting from the simulation. They are calculated as if the data were drawn from a normal probability distribution. As long as the resulting data set has a normal appearance (i.e., a bell-shaped curve), then the reported mean and standard deviation provide reasonable approximations of the true mean and standard deviation.

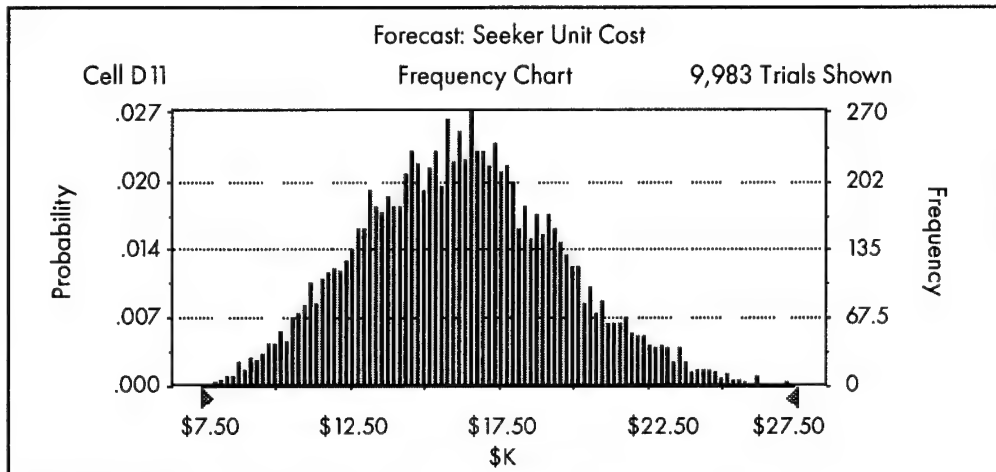


Figure 2. Seeker Risk and Uncertainty Analysis

In the absence of a risk and uncertainty analysis, the cost analyst might choose to estimate this cost element by calculating the seeker cost CER using a weighted average frequency.

$$(120 \text{ kHz}) \times (0.8) + (80 \text{ kHz}) \times (0.2) = 112 \text{ kHz}$$

$$\text{Seeker cost} = 0.41 \times (112 \text{ kHz})^{0.78} = \$16.26\text{K}$$

Notice that the point estimate is nearly identical to the mean cost calculated using the Monte Carlo simulation. However, the risk and uncertainty analysis provides significantly more information to the program manager.

PROCESSOR RISK AND UNCERTAINTY ANALYSIS

The program manager's cost analyst also discussed the properties of the processor with the engineer responsible for its design. According to the engineer, the processor is highly specialized and there are no analogous systems to be found. However, the analyst has found a CER that relates the unit cost of a processor to the

number of zener diodes contained in the processor. The engineer has estimated the possible number of zener diodes inside the processor with a triangular distribution. According to the engineer, the minimum number of zener diodes is 10, the absolute maximum number is 30, and the most likely number is 15. The processor unit cost CER is as follows.

$$\text{Processor unit cost (FY 96 \$K)} = 5.3 + 0.63$$

$$\times (\text{Number of zener diodes})$$

$$\text{Coefficient of variation} = 22\%$$

The risk associated with the processor is a function of the number of zener diodes required. The uncertainty is manifested in the coefficient of variation in the processor unit cost CER. This situation is modeled using a triangular distribution for the number of zener diodes and a normal distribution for the cost CER, as shown in Figure 3.

Based on a Monte Carlo simulation with 10,000 iterations, the mean unit cost estimate is \$16.83K with a standard de-

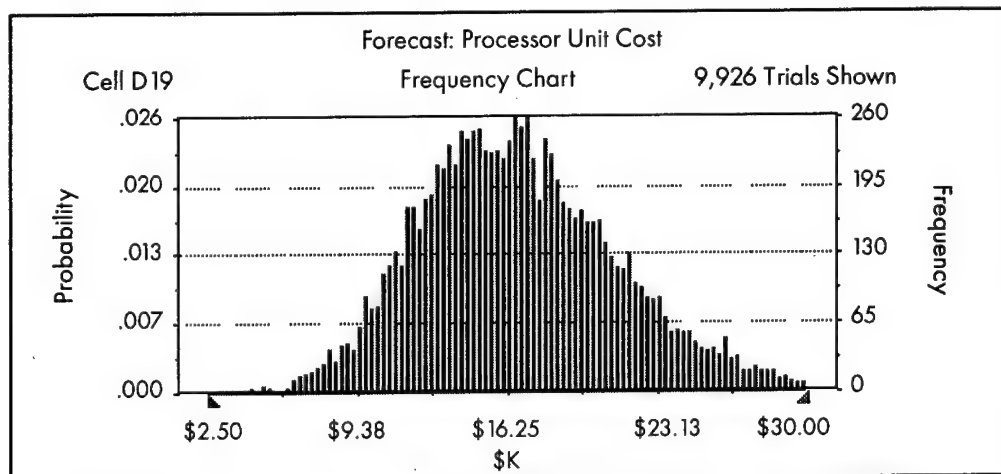


Figure 3. Processor Risk and Uncertainty Analysis

viation of \$4.64K. Therefore, we see a 68 percent chance that the true cost of the processor will fall within the mean plus or minus one standard deviation (\$12.19K to \$21.47K), while the range of nearly all possible costs is approximately \$2.50K to \$30.00K.

Again, in the absence of a risk and uncertainty analysis, the cost analyst might choose to estimate this cost element by calculating the processor CER using the most likely number of zener diodes, which was stated earlier as 15.

$$\text{Processor cost} = 5.3 + 0.63 \times (15) = \$14.75\text{K}$$

Notice that in this case, the point estimate is quite a bit less than the mean cost calculated using the Monte Carlo simulation. This difference is primarily due to the risk associated with the wide range in the possible number of zener diodes.

TOTAL GUIDANCE & CONTROL RISK AND UNCERTAINTY ANALYSIS

The total unit cost for the guidance and control is the sum of the cost estimates for both the seeker and the processor. However, since we are no longer dealing in just point estimates, it is appropriate to run one more Monte Carlo simulation, where, on each iteration, the random observations for the seeker and processor are summed and the result is the random observation for the total unit cost. Figure 4 shows the results of this exercise.

Based on a Monte Carlo simulation with 10,000 iterations, the mean total unit cost is \$33.10K. Note that this number is simply the sum of the mean costs for the seeker (\$16.27K) and the processor (\$16.83K), as one would expect. The standard deviation for this cost distribution, however, is \$5.71K, which is less than the sum of the standard deviations for the seeker and processor. These phenomena are consistent with statistical theory.

The smaller standard deviation leads to an interesting result. When summed to-

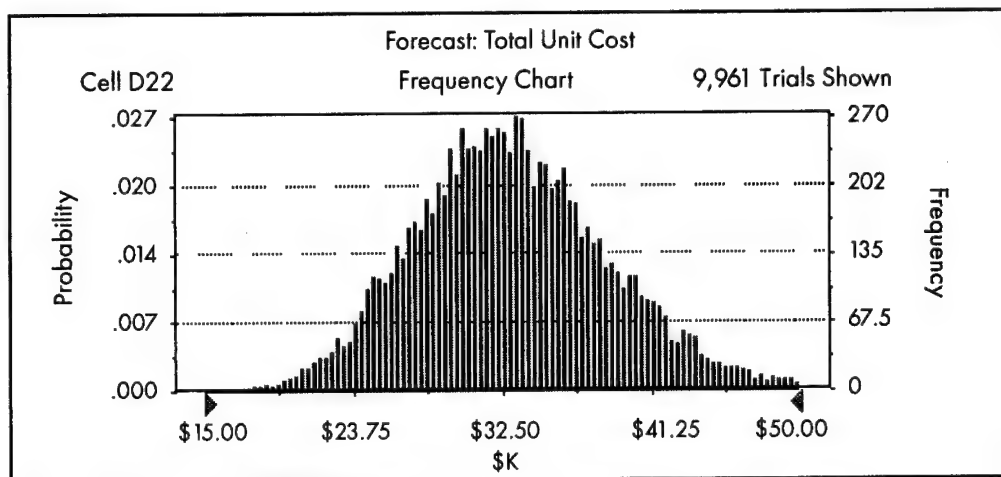


Figure 4. Total G&C Risk and Uncertainty Analysis

gether, the total unit cost estimate has a tighter range than if one had simply summed the endpoints of the two sub-elements. For example, the lowest observed cost for the seeker was \$7.50K, while the lowest observed cost for the processor was \$2.50K. Summed together, one might expect the lowest observed total cost to be \$10.00K. However, since summing the two sub-elements has reduced the overall variance, we find in the simulation that the lowest observed total unit cost is actually \$15.00K. A similar result occurs with the highest observed costs. Instead of the summed value of \$57.50K, the simulation shows that the highest observed cost of the sum is actually only \$50.00K. Thus, the more we aggregate the cost elements, the more precise our cost estimates using this methodology.

Therefore, for the total G&C, we have a 68 percent chance that the true cost will fall within the mean plus or minus one standard deviation (\$27.39K to \$38.81K)

while the range of nearly all possible costs varies from \$15.00K to \$50.00K.

SUMMARY

This primer illustrates the benefits available to program managers and milestone decision authorities when a proper risk and uncertainty analysis is performed on a baseline cost estimate. What the reader should gain from this article is an appreciation of the superiority, from a decision-maker's perspective, of a point estimate with a risk and uncertainty analysis, as opposed to a point estimate alone. The reader should also understand the increased responsibility of the cost estimating analyst with respect to data collection, in that all data used in creating a cost estimate must include range or variability assessments.

ACQUISITION OF STATE-OF-THE-ART LOGISTICS COMBAT SUPPORT SYSTEMS: THE JOINT LOGISTICS ADVANCED CONCEPT TECHNOLOGY DEMONSTRATION PROGRAM

Alan E. Barrick and Henry C. Alberts

The past few years have seen major changes in the policies used to acquire weapon systems. Change has come from three sources. One is congressional actions (passage of Pub. L. 103-355, the Federal Acquisition Streamlining Act of 1994, and subsequent language in authorization and appropriation bills for fiscal years 1995 and 1996). Another is Department of Defense (DoD) policy changes (such as DoD's Commercial and Non-Developmental Items [CANDI] and Open Architecture initiatives), and the third is publication of the "Joint Logistics Commanders' Guidance on the Use of Evolutionary Acquisition Strategy." Here we describe how these changes in acquisition philosophy have been applied to rapidly develop, field, and operate a combat logistic support system that has successfully supported joint activities within three major commands.

This article is written with the expectation that lessons learned during Phase I of the Joint Logistics Advanced Concept Technology Demonstration (JL-ACTD) can help others involved in programs to incorporate newly available technology into the equipment provided to our combat forces.

In today's global environment, our military forces are employed in joint and multinational operations. Improving their ability to operate in those modes must be a major DoD objective. The Joint Logistics Advanced Concept Technology

Demonstration (JL-ACTD), an Office of the Secretary of Defense-sponsored acquisition demonstration, was initiated to provide a logistics decision support tool for theater commanders-in-chief (CINCs) and combined joint task force (CJTF) commanders.

At the operational and tactical level, the focus of Service logistics will shift from "supporting units and areas" to "projecting and sustaining force capability." Specifically, logisticians will concentrate on the consolidation of management activities and eliminate the myriad of stovepipe functions (e.g., supply, maintenance, and transportation). Having appropriate communications will make it possible to see available total assets and have complete in-transit information. These attributes will consolidate into a reliable, disciplined, and responsive system that provides weapon system sustainment to combined forces.

In the "combined operations" future, logisticians will have to work through a fog of varied, unknown, and unpredictable threat scenarios. Therefore, the new logistics activity must have training modules

that simulate force equipment projection, equipment utilization rates, and force consumption rates of classes of supplies. This will permit planners to "see" the effects of their decisions on expected force and weapon system sustainability. Incorporating such modules will also enable logisticians to: (a) consider issues of ad hoc support to coalitions; (b) evaluate alternative mechanisms for tailoring capacity based logistics; (c) assess the potential for improving bare base operations; (d) analyze increased use of civilian and host nation support assets; and, (e) conduct tradeoff analyses of plans for deployment (either before, or concurrently with combat forces).

Warfighters provided the definition of an appropriate end product requirement. They modeled and analyzed logistics processes from a joint perspective, deter-

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mined opportunities to improve that process, and identified the characteristics of systems most capable of providing for those needs. This process defined the program objective: Give CINCs and CJTFs the capability to plan and execute more responsive and efficient logistics support. Phase I of the JL-ACTD satisfied this goal by providing warfighters with integrated, accurate pictures of pertinent battle space from a joint perspective in real time. Doing this required real-time integration of a tremendous amount of information presented in many different formats.

It was envisioned that the JL-ACTD would provide battlefield awareness necessary to permit all combat leadership to see the same battlefield, and to share the information required to permit joint decision making. That is, the JL-ACTD would provide the right information, at the right time, in the right place and in the proper integrated configuration for immediate use by decision makers.

But the needs of joint level Combat Service Support (CSS) planners for decision support systems vary significantly from echelon to echelon and from organization to organization. CSS planners at all echelons seek validated, integrated, high-quality automated systems to support their decision-making analyses. At the beginning of this program, direct access to relevant data was lacking, and interoperable mechanisms for summarizing and presenting data were virtually nonexistent. This lack of interactive connectivity and high-level interoperability created a myopic view of the situation, which resulted in lower quality plans and inefficient use of resources. Logisticians needed real-time information to be effective. Precise infor-

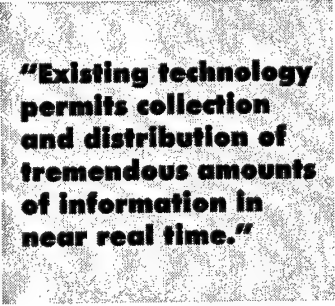
mation is needed to achieve precision logistics.

AN APPROACH TO MEETING THE CHANGING LOGISTICS REQUIREMENTS

Existing technology permits collection and distribution of tremendous amounts of information in near real time. Service components in each unified and specified

combatant command have logistics inventory and accountability systems that report upwards from the tactical level to the national level through a hierarchical network. But even though such systems exist within the services and defense agencies, they are "stovepiped" within the service's own logistics communities. As a result, these systems do not integrate those aspects of supply, maintenance, and transportation essential for making tradeoff decisions during planning and execution of contingency operations.

The former Under Secretary of Defense for Acquisition and Technology, Dr. Paul Kaminski, initiated the JL-ACTD program to develop a modern "precision logistics unified support" system for CINC and CJTF warfighters. In it, the amount and type of logistics information needed to satisfy warfighters' needs could be accessed, analyzed, and exchanged as needed, using a "common operating environment."



"Existing technology permits collection and distribution of tremendous amounts of information in near real time."

"From the outset, the JL-ACTD was established to permit adoption of a more efficient approach to the acquisition process."

An ACTD applies maturing advanced technologies in real-time operational scenarios to establish real-world practicability and operational utility. A successful ACTD will, upon conclusion, leave behind an in-place, resident operational capability that can be tailored, replicated, or

transitioned into an appropriate point of the formal acquisition cycle. From the outset, the JL-ACTD was established to permit adop-

tion of a more efficient approach to the acquisition process. As it has been pursued, the program has used the evolutionary acquisition (EA) methodology described in the Joint Logistics Commanders Guidance. The EA process has fostered rapid transition of emerging technology into a system that gives warfighters the ability to simultaneously develop appropriate doctrine and concepts of operation.

THE JL-ACTD PROGRAM

OVERVIEW

The JL-ACTD goal is to provide the warfighting CINCs and joint task force commanders with a robust capability to plan, execute, and monitor logistics operations.

The basic functional element of Phase I of the JL-ACTD is the Logistics Anchor Desk (LAD). The LAD concept was originally created by the U.S. Army Materiel Command and the Software and Intelligent Systems Technology Office of the Defense Advanced Research Projects

Agency (DARPA). The LAD (workstation) consolidates data from multiple sources, such as Automated Identification Technology, to provide situation awareness of current operations for the user. The initial "prototype" LAD leveraged existing components from the Army Research Laboratory's Knowledge-Based Logistics Planning Shell, the Transportation Command's (TRANSCOM) Analysis of Mobility Platform, and the Joint Total Asset Visibility (JTAV) program, for its initial capability to analyze current and future logistics operations. The LAD leverages the Army Research Laboratories' experience in logistics analysis and planning tools. This shared view of the battlefield is fed into models and simulations to support the development, evaluation, and analysis of courses of action. Through the use of collaborative planning and course of action analysis programs, the commander can "see" the unfolding logistical needs for strategic, operational, and tactical consideration.

The program was structured to have a two-year development phase followed by a user operational evaluation period. The prototype LAD concept was initiated by the Army Materiel Command in February 1994 as part of the Louisiana Maneuvers Program and was incorporated within the Army's Total Distribution Advanced Technology Demonstration (TDATD) in January 1995. After successful participation in Army and Joint exercises, and after briefing the Joint Logistics Commanders in January 1995, the program was established as a new ACTD on Oct. 1, 1995. (The success of the LAD led to its incorporation into the Army's TDATD in February 1995).

The LAD hardware and software configuration forms a system to function as a Logistic Decision Support Tool for CINCs and CJTF commanders. The program provided for phased installation and operation of 21 LADs at three separate CINCs over a two-year period. The CINCs annual exercises would provide a means for evaluating the LAD capabilities, defining and refining CINC operational needs, and facilitating the process for including LAD refinements in the fielded system. Figure 1

shows the elements of the LAD and how they are integrated to meet commanders' needs.

JL-ACTD CAPABILITIES EVOLUTION UNDER JOLT

The Joint Office for Logistics Technology (JOLT) was established in March 1997. The new organization is led by DARPA in close coordination with the Defense Information Systems Agency (DISA) and the Joint Staff Director of

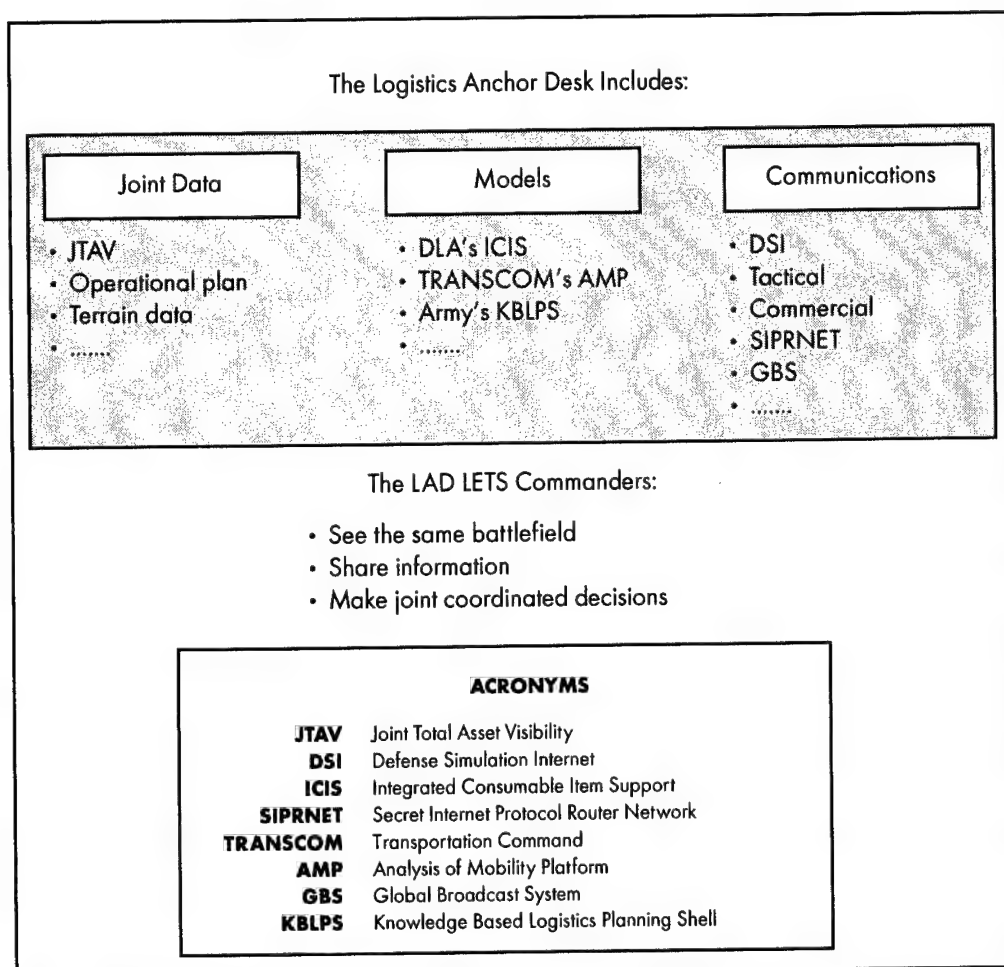


Figure 1. The JL-ACTD Logistics Anchor Desk

Logistics (J4). JOLT is responsible for the JL-ACTD. This includes transitioning Phase I (LAD) functionality to Phase II (Joint Decision Support Tools, or JDST) and to Phase III (Real-Time Focused Logistics). This action has four objectives. First is expanding the successes of the JL-

"These [support] tools will support logistics operations across the entire operational spectrum—mobilization, deployment, employment, sustainment, and redeployment."

ACTD Phase I and developing decision support tools to support all of the services, agencies, and CINCs. Second is strengthening the linkage between DARPA logistics technology initia-

tives and their logistics customers, and third is ensuring that JL-ACTD software tools can "plug and play" within the Global Combat Support System (GCSS) Internet environment. The fourth objective is continuing to provide "LAD functionality" to CINCs Central Command (CENTCOM), the Atlantic Command (ACOM), and the European Command (EUCOM). Phase I is currently transitioning products to the DISA GCSS.

The JL-ACTD Phase I (LAD), which was highly successful, ended in April 1997. During fiscal year 1997–98, the JL-ACTD Phase II (JDST) will develop specific joint, integrated decision support tools to provide CINC, CJTF, and service and agency planners the capability to plan or replan logistics operations based on actual asset visibility and control. These tools will support logistics operations across the entire operational spectrum—mobilization, deployment, employment,

sustainment, and redeployment. They will conform to all Defense Information Infrastructure (DII) standards and be accessible through GCSS. They will access data through the Joint Total Asset Visibility (JTAV), Joint Personnel Asset Visibility (JPAV), Global Transportation Network (GTN), Joint Operational Planning and Execution System (JOPES), or other existing or developing architectures. People, units, equipment, and supplies will be included. These solutions will be linked with other functional area initiatives such as the Advanced Joint Planning ACTD and the Battlefield Awareness and Data Dissemination ACTD. Specific objectives are to:

- provide a single, near-real-time, globally available view of operational logistics data from strategic to tactical level;
- improve operational awareness, collaborative logistics planning, monitoring, and analysis tools;
- provide tools to enable course of action assessment, execution monitoring, and dynamic replanning within the decision cycle window;
- build on existing decision support tools where applicable, and identify and develop new tools where none exist; and
- demonstrate initial data interoperability through a shared data environment in coordination with GCSS efforts.

During fiscal year 1999–2001, JL-ACTD Phase III (Real-Time Focused Logistics) will provide a seamless information and decision support capability

among combat service support and operations functions to support the warfighter. This information will be available on any workstation (hardware independent) and on one net (the Defense Information Infrastructure [DII] common operating environment [COE]), and will present one fused picture of the expanded battle space. Specific objectives are to:

- provide operational commanders increased combat power through greater control of the logistics pipeline;
- develop and demonstrate a complete, end-to-end, advanced logistics system for the planning, executing, monitoring, and rapid replanning of a major force deployment from the continental United States (CONUS) to in-theater final destination and return to CONUS origins;
- develop and demonstrate fine-grained course of action evaluation with access to supporting information and analyses linked to all other segments of the war plan;
- demonstrate total integrated logistics infrastructure requirements for dynamic replanning; and
- demonstrate collaborative J3 and J4 interoperability via integrated operations COE workstations to support planning and execution monitoring.

PARTICIPANTS

The Operational Users are: (a) the Commander in Chief, European Command; (b) the Commander in Chief, Atlantic Command; (c) the Commander in Chief, Cen-

tral Command; (d) the warfighting CJTF elements within the Commands; (e) the Joint Staff; and (f), functional support from the U.S. Transportation Command and the Defense Logistics Agency (DLA). LADs are currently at U.S. Air Force-Europe (Ramstein AFB) and U.S. Marine Corps Bases (Camps Pendleton and Lejeune). EUCOM continues to use LAD capability in support of Operation Joint Endeavor and Joint Guard. Both ACOM and CENTCOM have LADs within their organizations. DARPA and the service laboratories are providing technology. Twenty-one LAD units have been installed and are now operational in Europe and in the CONUS.

The LAD operating in Bosnia to support U.S. and Allied Force involvement there has been of special interest. This unit has been praised by the operational units and the CINC for the new capabilities it has provided.

RESIDUAL CAPABILITY

The JL-ACTD focuses on improvements to situational awareness, distributed collaboration capabilities, and tools for logistics planning, monitoring, and analysis. To this end, it will leave a network of workstations, interfaces to exercise and operational data, and communications within the CINCs operations and logistics planning cells. These residual capabilities will use data from the JTAV program, complement the operational planning ca-

"The JL-ACTD focuses on improvements to situational awareness, distributed collaboration capabilities, and tools for logistics planning, monitoring, and analysis."

pabilities provided by the Advanced Joint Planning ACTD, use the Battlefield Awareness and Data Dissemination ACTD telecommunications capabilities, and integrate into the emerging GCSS.

Most important, the LAD will be able to easily incorporate future technology advances that will give the CINCs the benefit of continuous system improvement to match change to their particular operational requirements. This advantage is a direct result of the way the system was designed using the evolutionary acquisition process.

THE JL-ACTD ACQUISITION STRATEGY

Streamlined acquisition and management processes have been used through out the JL-ACTD process, resulting in the choice of an evolutionary acquisition strategy as described in the "Joint Logistics Commanders Guidance for the Use of Evolutionary Acquisition Strategy to Acquire Weapon Systems." The JL-ACTD management concepts have been tailored in accordance with DoD Instruction 5000.2-R. Phases I, II, and III of the strategy, as mentioned previously, maintain the underlying principles of an ACTD: Prototype Development and Distribution; Joint Technology Applications; and User Assessment and Evaluation.

- Phase I. LAD was essentially limited operational use of the core LAD prototype capability. The JL-ACTD LAD prototype was dynamically configured from existing models, simulations, and tech base demonstration components using advanced knowledge-based systems engineering technologies. Inter-

faces could be tailored to specific user requirements to support user-specific tasks.

- Phase II. Joint Decision Support Tools is the formal assessment and incorporation of other laboratory and service initiatives, ACTDs, etc., that will enhance or increase the LAD prototype capabilities.
- Phase III. Real-Time Focused Logistics is the major objective of a seamless information and decision support capability, to be available on any workstation and DII- and COE-compliant. Upon conclusion, the success of the ACTD will be the transition to GCSS and into the appropriate point of the formal acquisition cycle.

The phases are not mutually exclusive: succeeding phases build on the results of previous phases and use the assets provided in that phase. Demonstration exercises have been used to provide a cost-effective basis for operational users to make informed acquisition decisions when required. In addition, management of the JL-ACTD will be monitored by a Transition Integrated Product Team, including representation from the principal co-sponsoring users, development organizations, and the Joint Staff.

PRESENT STATUS AND PLANS

PAST AND CURRENT EFFORTS

The efficiency and streamlining provisions obtained by selection of an evolutionary acquisition strategy permitted rapid progress through the first phase.

Significant achievements include the following.

October 1995. The JL-ACTD began supporting EUCOM Planning Cells for Operation Joint Endeavor. Currently, The JL-ACTD maintains five LAD sites in the European Theater, including one with U.S. forces in Bosnia-Herzegovina. EUCOM support resulted in requests for two additional CONUS sites; the Army Materiel Command Logistics Operations Center and the Joint Chiefs of Staff (JCS/J4). Although the EUCOM CINC was not part of the initial ACTD, its real-world mission provided a significant test bed for LAD development and enhancement.

February 1996. The JL-ACTD Program Office tasked RAND to conduct a study to determine how distributed collaborative planning and execution in Headquarters, EUCOM and US Army Europe (USAREUR), was being supported with capabilities provided by the LAD and related Total Asset Visibility (TAV) tools and processes. The JL-ACTD Office supports these organizations in contingency planning for logistics operations in Bosnia and surrounding regions. The RAND analysis and evaluation of operational support stated that the LAD accomplished the following.

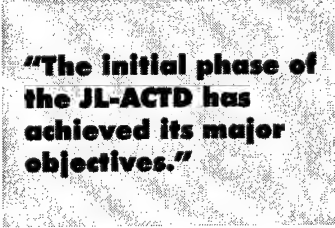
- It offered many information logistics capabilities on a single platform—movement, supply, maintenance, and engineering—and it provided efficient, deployable logistics information and automation.
- It provided useful planning and important second views for logistics planners and commanders.

- It was widely recognized as an important saver of staff time: it did real work faster, reduced staff coordination demands and busywork, and sped dissemination of authoritative information.
- It provided access to otherwise unavailable information (such as detailed, on-line National Imagery and Mapping Agency maps, and status of key assets).
- LAD video-teleconferencing contacts are confidence-builders.

September 1996. The JL-ACTD Phase I (LAD) Project Office provided its year-end report to the Office of the Secretary of Defense leadership and described its future planning for integrating its functions into the Global Command and Control System (GCCS). The Integration "In Process Review," also held during this period, provided a clear statement of activities planned for fiscal year 1997.

FUTURE ACTIVITIES AND TRANSITION TO AN ESTABLISHED PROGRAM

The initial phase of the JL-ACTD has achieved its major objectives. It has successfully demonstrated the viability and battlefield utility of Joint Decision Support Tools, the LAD concept, and the ability of current technology to provide for expanding functional logistic support capacity. The next major priority is to incorporate this demonstrated capability with an established program office while providing for ongoing sup-



"The initial phase of the JL-ACTD has achieved its major objectives."

port of the residual equipment functioning in the field.

Phase I was declared a success in April 1997. As a result, the Office of the Secretary of Defense leadership decided to migrate the program to the GCSS and to have the JOLT manage the (Phase I) residual capabilities through fiscal year 1997. DISA will serve as the manager for technical aspects of the GCSS and therefore will certify the Phase I software migrating to GCSS.

A number of major considerations are involved in transfer and integration.

Interoperability. Phase II (JDST) is a joint program. Any hardware and software selected must be compliant for use within the GCSS environment.

Requirements development. During the JL-ACTD, the CINCs have assisted in the requirements refinement process. The Operational Requirements Document (ORD) will be created by the CINCs and service components and the JOLT and completed as a part of the transition to the GCSS program.

Utility assessment. An assessment of JDST military utility will be conducted by the CINCs (ACOM, CENTCOM, and EUCOM) in conjunction with support from the Operational Test and Evaluation

Command.

Other assessments, as required, will be performed by other agencies. The report of acceptable military utility will be forwarded

"The JL-ACTD program has incorporated the concepts of evolutionary acquisition streamlining and reform throughout its execution."

from the CINCs through the Transition Integration Product Team (TIPT) to the Un-

der Secretary of Defense for Acquisition and Technology. The JOLT also will receive copies of this report.

Security. Upon transition, computer vendors who are planning new computer products that feature security or security-related improvements to existing products will initiate a preliminary evaluation. Technical exchange meetings will follow execution of nondisclosure agreements between all parties. The Computer Security Center will advise vendors about potential security strengths and weaknesses of the vendor design choices.

Organization. The transition plan and details of execution will be approved by the TIPT, consisting of the responsible Office of the Secretary of Defense, CINCs, Service organizations, and agencies.

CONCLUSION

The JL-ACTD program has incorporated the concepts of evolutionary acquisition streamlining and reform throughout its execution. Specifically, the program:

- applied an evolutionary product development and acquisition strategy to ensure that final products provided to CINCs met their needs;
- used an open systems design strategy to permit widest possible use of commercially available equipment and software—100% of the hardware components and 80% of the software embedded in all of its Phase I (LAD) and Phase II (JDST) devices used CANDI;
- conducted joint testing of equipment

with the operational forces and the JL-ACTD product development teams; and

- made provisions for Phase I products to adapt to changing requirements derived during operational activities.

The CINC users provided positive feedback during this program as a result of their involvement in Phase I's use of the evolutionary acquisition methodologies. The JL-ACTD executed the strategy as follows:

- "Tools" provided through Phase I enhanced the existing capability.
- Users increased their sophistication using the demonstrated capability, gained insight, and asked for increased functionality.
- Tool capabilities were then increased to meet or exceed the new user requests, and so on.

In fact, the Phase I experience indicated that when a proper capability can be established to modify product configuration and operation, an ultimate tool may not be established because the most useful tool is always dependent upon the sophistication of the user base.

But acquiring tools (or equipment) is only the first step. Well trained and motivated people are also required to get maximum effect from their use, and the tools must be integrated within an organization flexible enough or so structured to ensure both efficient and effective use. It is the consensus of users that "value can be added" through the demonstrated Phase I capabilities. Not only has the Phase I (LAD) added to operational capability, but the DoD JL-ACTD initiative has extended the logistic effort and provided a more comprehensive overview of a critical aspect of joint and combined operations.

In search of an explanation for Phase I successes, one may hypothesize that the use of modern product design and evolutionary acquisition methodologies permitted LAD operators to assimilate and manipulate information with an assortment of efficiently crafted tools to arrive at specific operational answers.

The key to success is access to information sources and the programmers' ability to resolve problems. Data access and programming ability, tracking logistics assets, and providing "what is" and "what if" in advance, is the key to both Phase II and Phase III potential that can be demonstrated real-time. The JL-ACTD is well on its way to developing a "precision logistics unified support" (PLUS) system.

A definite PLUS for the warfighter!

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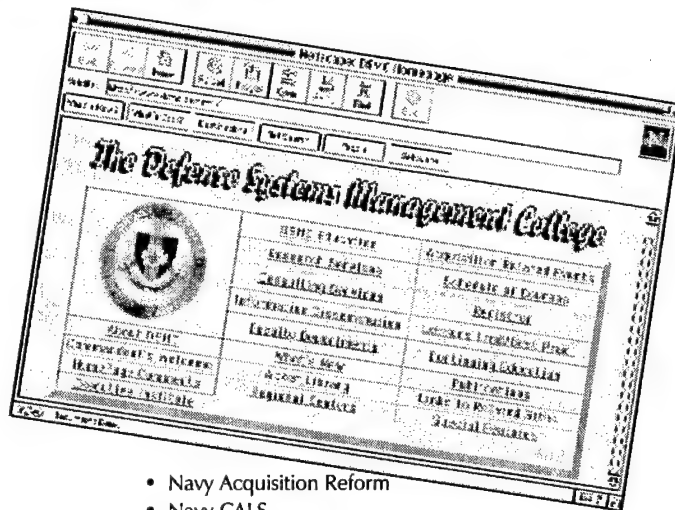
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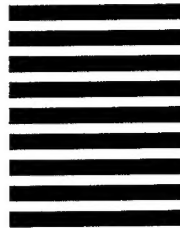
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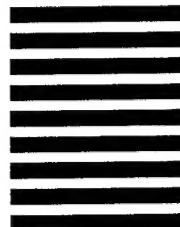
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